The Science of Nature: an introduction

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TO

VIRGINIA

"Whose art is always an imitation of nature"

(p. 57)

PREFACE

In contemplating a revision of my GENERAL SCIENCE OF NATURE, now eight years in print, I could have written a completely different kind of book, in a fresher idiom and with greater attentiveness to recent developments in the logic of explanation, the philosophy of nature, and the philosophy of science. Both philosophers and scientists in recent years have developed significant themes that should be the subject of serious consideration by anyone pretending to write a self-styled introduction to the science of nature. But within the time limits available, this more advanced and more controversial kind of book I might have written was ruled out for sheer practical reasons. The reader will therefore recognize in the following pages what is essentially an abridgment of THE GENERAL SCIENCE OF NATURE.

But aside from the problem of getting out a new work in the philosophy of nature within a time limit imposed by my publisher, there is a positive reason for the present book, and for the title of the book, THE SCIENCE OF NATURE: AN INTRODUCTION. It is being presupposed in these pages that a student is acquainted with none of the so-called philosophical subjects except logic, and the more complicated book I might have written (and still plan to write) would have been within the reach of only the more advanced student.

There are at least two conceivable kinds of introduction to the science of nature. One would be for the kind of reader already familiar with authors like Whitehead, Teilhard, Woodbridge, Boodin, Bergson, and Dewey. But this kind of introduction presupposes a mature knowledge of philosophy (and to a great extent of science) and invites a reader, having accumulated a great deal of analytical knowledge in a random and historical way, to go back to a carefully considered logical starting point for a rethinking of a synthetical outlook on the natural world. The other kind of introduction respects a reader who, knowing only fundamental logic, is being introduced through a book like this to philosophy itself. Such a work must reduce controversy to a minimum and can justify its noncontroversial spirit by starting with the first great philosopher of nature with whose claims subsequent thinkers have to be compared and whose views are thus presupposed to any other system. My present book is an introduction in this second sense. The introductory chapter may be bypassed by students, if necessary, and read according to the chronology in which it was written — last.

My gratitude must be expressed first to my wife, Virginia, for her never-ending encouragement in my work. I am indebted also to the Administration of St. John's University for its generous facilities in the preparation of my manuscript. Editorially, I am much indebted to Mr. William E. May of The Bruce Publishing Company, who edits manuscripts like the professional philosopher which he is. Finally, let me thank my secretary, Miss Barbara O'Neill, for the excellence of her work.

VINCENT E. SMITH

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INTRODUCTION

Because of the *extraordinary* exploits of modern science, beginning with the Copernican revolution, learned men often find the *ordinary* world uninteresting to explore and simply take it for granted. But not all present-day intellectuals share this viewpoint. Twentieth-century phenomenologists, like Edmund Husserl[1] or Maurice Merleau-Ponty,[2] recognize that in the end all genuine knowledge, scientific or otherwise, is conditioned by notions from the "everyday world." Linguistic analysts, like Ludwig Wittgenstein,[3] J. L. Austin,[4] and Stephen Toulmin,[5] point to the importance of "ordinary language." Until we understand the meaning of such language, meaning cannot be assigned to the artificial symbolism of the sciences. But phenomenologists and linguistic analysts are considered philosophers, and what is called science today is conceded to be the province of modern physicists, chemists, and biologists.

However he might differ from them, the Greek philosopher Aristotle would share with phenomenology and analytical philosophy an interest in the ordinary. He wrote technical works about the natural world in which he defended, for example, the geocentric astronomy. But he also wrote a more general type of work called the *Physics* in which he raised questions about the ordinary world as one meets it prior to specialized science and at the level of common experience. Here, according to Aristotle, the human mind forms its first notions about physical things. Such notions make up what we today call the philosophy of nature, but Aristotle thought that the first physical notions were part of natural science in his use of the term.

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1 *Phenomenology and the Crisis of Philosophy*, transl. Q. Lauer (New York, 1965).

2 *The Phenomenology of Perception*, transl. C. Smith (New York, 1962).

3 *Philosophical Investigations* (Oxford, 1953).

4 Austin uses the expression "linguistic phenomenology"; see his essay in V. Chappell, ed., *Ordinary Language* (Englewood Cliffs, N. J., 1965), p. 47.

5 *Philosophy of Science* (New York, 1960).

At first sight it may seem a mere exercise in the history of ideas to go back to a re-examination of Aristotle's *Physics*. Not only has his geocentric cosmology been overthrown, but new revolutions have taken place in the modern sciences where even the physics that overthrew Aristotle's has been surpassed. What can human reason possibly learn about our world that is not mediated by the so-called scientific method with its measurements and other exact experimental techniques? And what significant report can be made about the universe that does not use such concepts as those of atoms and their parts, the genetic code, the theory of evolution, the probability amplitudes of quantum physics, the space-time continuum of relativity, the theory of the expanding universe in recent cosmology?

But the latest word from recent science may not be the first word that the human mind can utter about nature. The modern scientist forms notions about physical things long before he starts his specialized work. What is change, time, place (or space), chance, causality, continuity? Questions of this kind form the subject matter of the *Physics*. They are raised at the level of ordinary experience of the ordinary world, and their answers are formulated in ordinary language. Aristotle's responses to these questions have to be tested in experience if they are to be considered seriously. But before such questions are even formulated, there should be a discussion at the level of methodology on whether the questions themselves are legitimate and whether they logically belong before, and not after, specialized science in forming a world outlook.

One way of showing the soundness of the questions is simply to recall that the ordinary world, proportioned to our natural sense powers, is the only world we directly experience in physical nature. When we are talking about the events at the interior of the atom or the stages of evolution in the remote past or the behavior of distant galaxies, our concepts are always formed from what we directly perceive. There may be value then in pausing to analyze our common sense notions to ascertain whether they are correct and to correct them if they are not.

But how do we know what notions to choose for analysis? Men of great learning have been wrong about what are now considered to be commonplace truths. The geocentric theory of astronomy lasted down to the seventeenth century, and just a century ago there was still a scientific debate about the spontaneous generation of living things. Such errors might lead us to mistrust the ordinary, even though all our concepts must be drawn from ordinary things. However, the kind of question we are trying to justify about the ordinary world is not formulated at such detailed levels as *how the earth and sun are in motion* with respect to each other or whether *life comes to be from non-life.* The questions at issue in this book are ones like: "What is *motion?*" or "What is a *coming to be?*" These questions are met prior to specialized science, and the answers, at least in unanalyzed form, remain forever a part of our physical concepts.

For it is apparent that knowledge in a human being is a process of going from hazy notions to more distinct ones. Whether learning arithmetic or learning about scientific entities like energy or light, the beginner's knowledge is always vague by contrast to the more clear and more distinct character such knowledge will have as the beginner progressively becomes an expert. If this fact of human learning is taken as a starting point, and if we then project this fact to the earliest stages of any individual's knowledge of the world, it can be argued that the vaguest of all notions occur first. It is with this general kind of ordinary knowledge, not with specific questions such as heliocentricism and spontaneous generation, that this book is concerned. The general issues are Aristotle's questions in the *Physics.*

Of the *Physics* Professor J. H. Randall, Jr., has written in recent years: "The *Physics* is really a philosophical introduction to the concept of natural science. As such, it is directly relevant to the criticisms we have now been making for a generation of the concepts of our inherited Newtonian philosophy of nature."[6]

As another approach to our methodology in justifying Aristotle's questions — without necessarily agreeing with his answers because they require experiential evidence — it may be argued that human beings can go through life without learning the law of inertia or the genetic code or the periodic chart. Such items pertain to specialized science, and only relatively few human beings have pursued this kind of knowledge. But it would be impossible to lead a normal human life without making an implicit commitment on issues raised by Aristotle in the *Physics,* such as the nature of motion or the nature of time. Our language bears witness to our possession of such general concepts as the answers to these questions. Thus we find it natural to refer to growth and change of place as different kinds of *motion,* showing that we acknowledge a general reality that the kinds have in common. No one could avoid a notion of what time is, even though he may never formulate such knowledge. Aristotle did not invent the big questions raised by his *Physics.* They belong to human

[6] *Aristotle* (New York, 1960), p. 169.

nature. Both in raising these questions and in searching for answers testable in common experience, the book makes copious use of the greatest of the Aristotelian commentators, St. Thomas Aquinas.

Such issues as the nature of motion or of time cannot be settled by measurement or any other kind of experiment. Answers to such questions are used in the formulation of all the other questions about nature; experiments, far from settling such issues, presuppose their settlement in an implicit and unanalyzed form. The only tools available to us in the analysis of realities like motion or time are common experience and basic logic. Again Aristotle did not invent either experience or logic. As John Locke remarked, God did not make man a two-legged animal and then leave it to Aristotle to make him rational.[7]

There have been other philosophers of nature in history besides Aristotle. Two important thinkers here are the twentieth-century philosopher, Alfred North Whitehead,[8] and Pierre Teilhard de Chardin.[9] What possible excuse can there be for neglecting these men and going to a fifth-century pre-Christian Greek?

To meet such an issue, recourse must again be taken to methodology. Teilhard, for instance, presupposes the empirical evidence for evolutionary theory which asks how the living world and indeed, in cosmogony, the whole universe, came to be as they are. This so-called genetic question which asks how things originated is extremely important, but it presupposes a prior knowledge of what it is that has originated and is now here before us. One cannot logically raise the issue of how a thing came to be unless he has a logically prior notion of what the thing is. Teilhard's views may be regarded as a candidate for the latest word about nature. But they presuppose the first word. Teilhard's book, *The Phenomenon of Man,* is not *The Science of Nature: An Introduction,* but *The Science of Nature: A Synthesis.* Teilhard's views are thus not to be compared as though competing with ideas developed in the present book. He asks questions that depend upon the solution to prior questions, including even the very sophisticated questions raised by modern science. These sophisticated questions have to be asked, but they are not on a different methodological level from those which deal with the analysis of the ordinary.

Whitehead too is an important philosopher, but not a rival to the

[7] *Essay Concerning the Human Understanding,* II, ed. A. Fraser (New York, 1961), p. 391.

[8] *Process and Reality* (New York, 1960).

[9] *The Phenomenon of Man,* transl. B. Wall (New York, 1959).

philosophy found in this book. Like Teilhard but in a different context, he presupposes evolution. But the principal problem in dealing with Whitehead, as a philosopher of the ordinary, is the extraordinary character of his language. His idiom includes such terms as "actual entity," "eternal object," and "concrescence." The language of Aristotle, on the other hand, is more familiar, even though in the course of intellectual history, terms like matter and form have been extended far beyond their original meanings. Yet there is evidence that the original meanings themselves have never been entirely lost. As in the case of Teilhard, our qualification against Whitehead does not imply a rejection of his views; it involves only a logic and language of starting points.

As an introduction to natural science this work assumes, on good logical grounds, that when the mind works toward a synthetic view of nature like that proposed by Whitehead and Teilhard, its initial moments are not physics, chemistry, or biology but something more general which is presupposed by modern science. So the synthetic knowledge of nature, which requires of course a previous knowledge of the elements to be synthesized, does not begin with science in the modern sense of the term.

But (as a parenthetical question here) why not make a so-called philosophical introduction to natural science a study of human persons? Why not make this philosophical starting-point a study of what is called subjectivity? Personalism, which is obviously an emphasis on human persons, is having a great vogue at the present moment of intellectual history — and rightly so.

But personalism cannot supply a logical introduction to a synthetic natural science. It must first be established, on logical grounds, that persons are important — the most important entities in this world. Before dealing with what it is to be a human subject by contrast to a mere fact or thing or object, the mind must, in a logical manner, establish the place of man in the cosmos and the eminence of the "I" and "thou" over the mere "it." To search out the nature of man and the importance of man as the pre-eminent reality in our world requires first raising the more general questions as those proposed in this book. Then, at a later moment and given the uniqueness of man as having been previously established, the philosophy of subjectivity and personalism can truly be invoked for all that it is worth. Once again, this is not to deny the great value of personalism or of the reflections on human subjectivity. As in the case of the philosophies of Teilhard and of Whitehead, it is a matter of the logic of questions and of what questions belong first in our initial and analytical approach to reality. Our concern again, as in previous parts of this introduction, is with the logic of starting-points. Personalism, with its accent on human individuals in their individual situations, must follow a universal science of nature in a logical synthesis, just as a consideration of generality precedes attention to particularity. Personalism or the philosophy of subjectivity is not *The Science of Nature: An Introduction* but *The Science of Nature: A Conclusion.*

Aristotle dealt in his *Physics* with the kind of generality that *precedes* specialized science; Teilhard and Whitehead, to a certain extent, deal in generalities that *follow* such specialized science. But in our concern with the general in the following pages a careful distinction must be made between a logic based on universals and one based on classes. A class is a collection; W. V. Quine refers to "the *principle of extensionality* . . . according to which a class is determined by its members."[10] This viewpoint should be contrasted with an intensional logic in which entities are grouped together because of what they have in common. Thus *man* is not just a collection of men having nothing in common except a name. *Man* is not a class but a universal.

If a so-called universal is nothing but a collection or class and if the only admissible logic is an extensional one, the whole concept of a general science of nature will be misunderstood. Those who accept only a logic of classes and only an extensional logic could never support the view that there are general notions prior to the more distinct and specialized notions like those articulated in the specialized sciences. So within a class logic that is built on the principle of extensionality (without intensionality), general notions could never be primary. They would always have to result from a count of what is less general and ultimately singular. Any initial generality would never be in concepts but only in an arbitrary agreement on the use of names. The following pages presuppose a logic based on universals and not on mere collections or counts. On such a view, universals are not mere names or even mere concepts; things like cats really do have an intrinsic likeness, and this is the basis for our forming universal concepts and assigning common names.

This proposal is not a mere dogmatic declaration of a program. It can be supported by evidence. For things cannot be collected in the same class unless the mind discovers that they have intrinsic likenesses to each other that form the foundations of universal ideas.

[10] *From a Logical Point of View,* 2nd ed. (New York, 1963).

In counting or collecting cats, not even the first two members could be put into the same "class" unless the collector of physical things (who in practice differs much from the scientist portrayed by modern logical theory) saw characteristics in some way common to both of them; thus, far from getting a whole class from the principle of extensionality, one could not even get the first two members without employing the principle of intensionality that in turn depends on a recognition of universals. Thus, a class logic, as truly practiced by scientists, would presuppose a logic based on universals. Such a verdict does not deny a logic of classes; it affirms only that such a logic is not primary. To paraphrase what has been so far argued, the mind begins its study of nature with the haziest, most general, most common notions that are later rendered more precise not by a count but by working from more universal notions to more precise and specialized notions. To move from the notion that man is an animal to the less universal notion that man is rational is not a problem of counting or collecting but of going, within the same object of thought, from a more universal or generic level to a less universal and specific level. A universal is not a mere name, nor a mere concept. Cats and dogs do have an intrinsic likeness of some sort. They are, for instance, quadrupeds. Hence there is some kind of community between them which is not just a matter of words or of thoughts. Both cats and dogs (unless crippled) *really* walk on four legs.

To make our methodology more concrete, what is more generic in a physical thing is recognized by the mind prior to what is more specific if it is true that we begin with the haziest of notions about our world and work our way down, as though from genus to specific differences, to what is more distinct. That man is an animal is more evident than that he is different from other animals, and that he is a movable or changeable being is more generic still. If the mind has the haziest conceptions of objects before clearer and more distinct notions obtained through modern experimental sciences, then there should be a problem, prior to the recognition of the various kinds of change — such as local motion (modern physics), changes of substance (modern chemistry), life processes (modern biology) — and the problem involved is that of the nature of change in general. And if the more generic and more specific parts of the reality like motion, time, chance, continuity, etc., are simply more generic and more specific parts of the same object, then a class logic that would put the "more generic" characteristics of a thing in one collection and the "more specific" characteristics in another will not do. A general science of nature as discussed in the following pages is general not in the sense of a count but in the sense that in regard to a single entity like man, the more universal aspects of the same object, e.g., man's animality, are better known than the more specific aspects, e.g., man's rationality. Are there notions about the material world still more generic than the animality of man and hence formulated prior to animality? Such a question must be answered in the following pages. Our concern in this introduction is not with the evidence for answers but with the logic of questions.

In this introductory section, there is one more important distinction to be drawn which is presupposed but never fully articulated in the following pages. It is a differentiation between a natural science and a mathematical physics.[11] The meaning of nature (and hence of a science of nature or natural science) is discussed in Chapter III. But prior to this discussion, some preliminary indications may be useful.

Our ordinary language would find it usual to say that it is of the nature of a fish to swim, of a bird to fly, of a worm to crawl, of a man to walk on two feet. But a treatment of these notions in mathematical physics would reduce all of them to lines in space. In mathematical physics, it would be meaningless to distinguish between, say, swimming and flying; a frame of reference, direction, speed, acceleration, and other quantitative variables are all that matter. Mathematical physics thus leaves aside some of the fundamental questions about our physical world. One line in space, representing swimming, and another such line, whether longer or shorter, straight or curved, representing crawling, does not express, by its merely mathematical formulation, the undeniable physical differences between such motions. Mathematical physics studies only the quantitative characteristics of motion; it abstracts from such differences as that of a fish making a felt effort against the tide and that of a projectile, moving according to the law of inertia, against a quite different kind of qualitative force. Both the swimming and the motion of, say, a baseball are reduced in mathematical physics to the same category, that of the quantified.

By contrast to a mathematical physics, a science of nature or a natural science studies things by their motions as peculiar natural

[11] See my *Science and Philosophy* (Milwaukee, 1965), ch. VII; cf. also F. Woodbridge, *Aristotle's Vision of Nature*, ed. J. Randall, Jr. (New York, 1965), p. 13.

motions rather than by the quantifiable characteristics of such motions. A natural science would consider swimming and crawling as different kinds of operation or motion, whereas mathematical physics would reduce both of them to a common denominator involving only such non-qualitative characteristics as mass, force, and coefficient of friction. Mathematical physics is thus a quite different kind of science from a subject like biology which — even though at times, as in genetics and population studies, it is a mathematical physics — is an overall natural science; to show this one need only point to the theory of evolution or to the taxonomist who finally decides whether two things are members of the same species by examining their operations, such as their being interfertile.

This book, as an introduction to natural science, depends on a distinction between a strictly physical or natural approach to nature and a mathematical-physical science. The physical (from *physis*) and the natural (from *natura*) represent Greek and Latin ways of saying that different things like fish or snakes have different tendencies from within themselves like the penchant for swimming in a fish or for crawling in a worm; and if local ordering of the inanimate world is to be explained, similar tendencies to natural operations must be argued for each type of natural thing, though we may not have enough knowledge to know what the tendencies of non-living things are immediately directed to. Nor will such knowledge ever be attained by mathematical physics, which leaves natural motions — the difference between crawling and swimming — out of account. But in view of the recognized order in our world, there must be as much natural tendency among non-living things to their natural operation as there is a tendency of the fish to swim or of the snake to crawl.

The following pages are intended as a first chapter to a natural or physical science of nature. Mathematical physics is a different kind of science. Yet mathematical physics itself requires physical interpretation, and such a requirement, if it is to be realistically met, returns us to the natural, the ordinary, and finally to the most general level of our ordinary knowledge of nature. Herein lies the relevance of a so-called introduction to natural science.

There are, in fact, two types of modern science: natural science such as evolutionary biology on the one hand, and a mathematical physics such as Newtonian, quantum, and relativity mechanics on the other. These two modern sciences relate in different ways to what we have termed an introduction to natural science or a general science of nature. But the differences in question are too sophisticated to be explored at this point.

There is no easy solution to the problem of science in its relation to philosophy. The reader should learn each of his subjects concerning nature — natural science, mathematical physics, etc. — on its own. How they all fit together requires more knowledge and more critical ability than any beginner can claim. And since this book is written as an introduction to natural science, the student's personal synthesis of natural science, if it ever comes, must be left to a later and much more sophisticated knowledge of the various subjects to be synthesized. In view of the complexity in our ever expanding knowledge of nature, such a synthesis, complete down to detail, is far beyond the reach of any single man. But short of it, in our quest by reason's own resources, of the meaning of our cosmos and the meaning of man, it is important to make sure where our analytic knowledge of nature begins. Without such knowledge, modern scientific research can proceed, but it will lack a baseline for whatever meaning human reason can discover, explain, and in the ideal case bring together.

THE SCIENCE OF NATURE:

an introduction

CHAPTER I

THE GENERAL SCIENCE OF NATURE

I. THE NATURE OF SCIENCE

a. Three characteristics of science

Science is a certain knowledge of things in terms of their proper causes.

This definition, formulated first by Aristotle,[1] has one great claim in its favor. It springs from the nature of man, the rational animal. That is why it is so worth considering.

1. To be rational or to reason is to seek *causes* and to construct syllogisms of that implicit type we call an enthymeme. Scientists are always seeking reasons or grounds why events happen as they do, why water evaporates, why some elements are heavier than others, why characteristics of living things are passed on from parent to offspring. One of the favorite words of a scientist is "because." Water evaporates because of the application of heat. Some elements are heavier than others because they contain a greater number of the fundamental particles called nucleons. Characteristics are handed down from parent to offspring because of the genetic code of the species. All of these arguments, typical of science, are implied syllogisms in which the middle term represents the cause for the connection between the objects represented in the conclusion.

2. The rational animal seeks certain knowledge. It is true that many of the propositions of philosophers are only opinions and that many of the laws of science, especially in physics, are expressed as probabil-

[1] *Posterior Analytics,* Bk. I, ch. 2, 71b, 8–16. This work is found in *The Basic Works of Aristotle,* ed. R. McKeon (New York, 1941).

ities. Moreover, there are revolutions in science when old theories cease to be all that was previously claimed for them and new theories are born. But the fact remains that doubt is not satisfying to the human mind. Man wants certitude, and this aspect of Aristotle's definition proposes a kind of model toward which a scientist works even though he must very often settle for less. Frequently a proposition taken as certain is later proved wrong.

3. The scientist wants to know the *proper* or precise causes for the things he studies. The proper reason why an isosceles triangle in Euclidian geometry has the sum of its interior angles equal to a straight angle is not that it is isosceles but that it is a triangle.[2] Nineteenth-century chemists were wrong (but understandably so) in assigning so much importance to atomic weight as the clue to the distinction between elements. The reason for this distinction is to be found in the number of protons in the nuclei of the various elements. The differences between elements are a matter of atomic number rather than atomic weight.[3]

Aristotle's theory of science is thus relevant to the work of the modern scientist. The reason is that the view of science just outlined is based on the very nature of human reason, and human reason is the same today as it was when Aristotle wrote. Man is still a rational animal. The Greek view of science may be seldom attainable in all of its three parts, but it is an ideal or model toward which men strive in the pursuit of scientific knowledge.

b. Demonstration, the ideal form of science

The work of science involves a great many operations: the formation of hypotheses, inductions, analyses, syntheses, definitions, etc. But in that ideal or perfect state we have just outlined, *science takes the form of what the logician calls a demonstration, a syllogism whose middle term represents the proper cause for what is represented by the conclusion.*[4] The following is an example:

> Whatever is spiritual is indestructible.
> The human soul is spiritual.
> Therefore, the human soul is indestructible.

Such a demonstration may be called causal (*demonstratio propter*

[2] A proper cause in the order of things is represented by a "commensurate universal" in the order of logic. *Ibid.*, Bk. I, ch. 4, 73b, 26–28.

[3] The atomic number of an element corresponds to the number of protons in the nucleus of the atom, atomic weight to the number of nucleons, i.e., protons and neutrons, in the nucleus.

[4] *Posterior Analytics*, Bk. I, ch. 2, 71b, 20–23.

quid) because it gives the real cause or reason for what is expressed by the conclusion.[5] The middle term, "spiritual," expresses the reason or cause of the indestructibility of the human soul.

Now let us consider another type of demonstration:

> Whatever is capable of acting independently of matter is spiritual.
> The human soul is capable of acting independently of matter.
> Therefore, the human soul is spiritual.

Here, the middle term, "capable of acting independently of matter," does not represent the real cause of what is expressed by the conclusion. It represents rather the cause of our knowledge of what the conclusion states. This kind of demonstration is called factual (*demonstratio quia*).[6] If we argue from the nature of the sun to the character of sunlight, we move from real causes to real effects. On the other hand, when we reason from the character of sunlight to the nature of the sun, we are going from effect to cause. We are using as our middle term a cause of knowledge. Sunlight does not really cause the character of the sun; it is the cause of our knowledge of the character of the sun.

II. THE CHARACTER OF FIRST PRINCIPLES

a. The notion of first principles

In exploring the conditions for the certitude of scientific knowledge, we must always remember that the middle term of a causal demonstration represents a certain and necessary cause or principle. *Now a principle is that from which anything flows in any manner whatsoever.*[7] It comes from a Latin word (*principium*) that means "beginning," and it would not be a bad definition to call the principle of anything that from which the thing begins. A point is a beginning or principle of a line. A parent is a principle of a child. A principle, then, is a source or starting point. It implies a process and order within that process;[8] wherever there is order there is at least one principle.

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[5] St. Thomas, *Exposition of the Posterior Analytics of Aristotle,* Bk. I, les. 23, transl. P. Conway (Quebec, 1956); *Summa Theologiae,* I, q. 2, a. 3; *Commentary on the Nichomachean Ethics,* Bk. I, les. 4, n. 51, transl. C. Litzinger (Chicago, 1964).

[6] St. Thomas, *Exposition of the Posterior Analytics,* Bk. I, les. 4, les. 23.

[7] St. Thomas, *Summa Theologiae,* I, q. 33, a. 1; Aristotle, *Metaphysics,* Bk. I, ch. 1, passim, in *The Basic Works of Aristotle, ed. cit.*

[8] St. Thomas, *Commentary on Aristotle's Physics,* Bk. I, les. 1, n. 5, transl. R. Blackwell, R. Spath, and R. Thirkel (New Haven, 1963). Books I and II of the *Commentary* are also available in English in R. Kocourek, *An Introduction to the Philosophy of Nature,* rev. ed. (St. Paul, 1951).

A principle is not the same as a cause. It may be a cause, as a parent is a cause of a child. But there are also principles which are not causes, like the point on a line. Principle implies orderly origin; but it does not imply dependence. A cause, on the other hand, necessarily involves dependence. A cause is indeed a principle, but a principle from which something proceeds with dependence. It is that on which a thing (the effect) depends in being or in coming-to-be.[9] Thus, every cause is a principle but not every principle is a cause. For the purposes of this book, however, the distinction between cause and principle is not always of importance, and the terms will be frequently used interchangeably. To say that the middle term of a syllogism represents a cause is to say that it expresses a principle, and vice versa.[10] Finally, principle will be considered in the following pages as a "reality" like a cause and not as merely a logical entity, e.g., a premise in a demonstration.

The characteristic of the demonstrative syllogism is that the middle term causes certitude, and, to achieve certitude, the true scientist (in Aristotle's sense of the word) must begin not with any principle whatsoever but with *first* principles. In order to explain this, it will be instructive to define and to illustrate first principles and then to defend the proposition that without first principles there is no science (again taking science in that ideal form, seldom reached in the concrete, which is based on the nature of man, the rational animal).

First principles have two characteristics:[11] Everything in the order under consideration is derived from them and they are underived within the order in question. In other words they are: (1) the ultimate sources for everything in the order under consideration; and (2) they are themselves underived or presuppositionless in the order wherein they operate.

b. First principles as sources

A unit is the first principle of arithmetic.[12] From it, everything in arithmetic is derived. To be sure of our equation, $2 + 1 = 3$, we have to analyze 2 into the units it contains. Should anyone challenge our equation, we would resolve the 2 into its two units and show that the additional unit in the 1 makes our answer to come out 3; we are proving our point by showing that there are three units in our sum. Once we

[9] St. Thomas, *ibid;* also *On the Power of God,* q. 10, a. 1, reply 8, transl. English Dominican Fathers (Westminster, Md., 1952).

[10] St. Thomas, *Principles of Nature,* ch. 22, available in English in R. Kocourek, *op. cit.*

[11] *Commentary on the Physics,* Bk. I, les. 10, n. 77.

[12] *On the Power of God,* q. 1, a. 3, reply 8.

have the habit of correctly solving problems in arithmetic, we would never have to check such a simple equation as $2 + 1 = 3$, and no one past the first grade would challenge us to do so. Knowledge of the unit, consequently, is only implicit in most of our mathematical knowledge; but it must be made explicit at least at the beginning of the science of arithmetic; and it remains as an implicit condition and checkpoint thereafter. It is the source, hence principle, of all our scientific or certain knowledge in the arithmetical order and constitutes the ultimate basis for all the certitude achieved in this order.

Within the family of subjects we already know, grammar has for its first principles the noun and the verb and geometry, the point and the line. From the unit everything in arithmetic is derived; the noun and the verb are the sources of all grammar; the point and the line are the starting points of geometry. *A first principle is the source, within an order under consideration, of everything in that order, and if there is any scientific knowledge of nature (according to the model of science based on man's rational nature), first principles must be found in the physical world.* Whether there are such principles will be a crucial question in this book.

c. First principles as underived

The second characteristic of a first principle is that it is underived within the order under consideration. Thus the unit is not derived within arithmetic, nor the noun and the verb within grammar, nor the point and the line within geometry.

As a principle of number, the unit for instance is no mere sum of fractions like $\frac{1}{2} + \frac{1}{2}$. To understand the numerator 1 and denominator 2 in each of the foregoing fractions an understanding of the unit is required, and the case would be similar if the $\frac{1}{2}$'s themselves were broken down into still smaller fractions *ad infinitum.* It makes sense to ask: "How many is two?" Such a question can be answered in the science of arithmetic. But to ask the same question about the principle of number: "How many is a unit?" is meaningless.

In a similar way, the grammarian cannot speak of the noun and the verb without using them or their synonyms; if only for this reason it can be seen that these two principles are underived in grammar. All other parts of speech are derived from them as their modifiers.

III. SCIENCE AND FIRST PRINCIPLES

a. The need for first principles

With this brief background of what first principles are and how they are relevant to sciences we already know to some extent, it can now be asked how the notion of a first principle relates to the definition of science as a certain knowledge in terms of proper causes. By way of answering such a question, it has already been hinted that first principles are necessary for the certitude of a science. A demonstration may obtain its premises from other demonstrations, but in the last analysis a science must rest on principles that are indemonstrable because they are evident in themselves.

Such a verdict does not mean that first principles are presented to us in a clear and distinct way and without any analysis on our part. What self-evidence means and how the mind comes into contact with self-evident principles are questions that will have to be postponed until we begin our quest, in the next chapter, for the first principles of nature. It is important here only to note that if first principles in any order are the source of all our knowledge in that order, any attempt to demonstrate them in the order under consideration would have to apply them and beg the question. Any project to derive the unit by arithmetical demonstration would have to use the unit. To say that the unit is underived in arithmetic is to affirm that it is not demonstrated in arithmetic, and in a similar way none of the sciences can demonstrate what they themselves must always employ whenever they make any demonstrations.

First principles assure the certitude of scientific knowledge,[13] *because in the study of any subject like number or the universe they give the mind some absolute and unconditioned starting point.* If the student of arithmetic did not begin his science with reference to the unit but chose instead to begin with some derived operation like $7 + 5 = 12$, he could never be certain of his conclusions, he could never check them, he could never defend them against doubt and denial. The checking of any equation in arithmetic requires, it was observed, an analysis of the expression that would eventually bring us to the number of units it contains.

A traveler going to Chicago but not knowing his point of departure could reach Chicago only by the merest accident; in reading a map to find out how to reach a destination we have to know where we are. Like a journey, science involves a series of parts that are ordered. Since any order requires a principle, a permanent and necessary order, like certain knowledge, which is science, requires permanent and necessary principles to certify it.[14]

[13] *On Truth,* q. 11, a. 2, reply 17; a. 1, reply 13; q. 12, a. 1; q. 16, a. 2; Aristotle, *Physics,* Bk. I, ch. 1, 184a, 9–16.

[14] *On Truth,* q. 22, a. 1; q. 14, a. 9.

b. "Science" without first principles

Imagine a student in quest of certain knowledge through causes and beginning the quest not with first principles but with principles that are somehow derived and relative. *Since these secondary principles depend upon primary and ultimate ones which our imaginary student leaves unexplored, it is possible that the conclusions he draws from these secondary principles will demand revision in the light of the first principles left unanalyzed but later explored.* Since first principles govern the entire realm investigated in a scientific study, any conclusions based only on secondary principles may be upset when first principles are later discovered and applied to the secondary ones. Nothing short of first principles can assure certitude in science.

To begin the quest for certitude by considering the derivative and secondary — like $7 + 5 = 12$ in arithmetic or the preposition in grammar — is like building a house without bothering to investigate whether the soil is hard or soft or even made of quicksand. To judge a man by his color or height once again gives priority to what is secondary; what is primary is his rational nature. If we judge the physical world without distinguishing the secondary from the truly primary, a blurred picture of the physical world will be developed. The facts established by modern physics, chemistry, and biology may, like the color of hair and the height of people, be well-established truth; and theories, like those involving the atom and the evolution of living things, may well rank among the greatest triumphs of the human spirit. No one could quarrel with a single fact of modern science nor should he reject a single theory unless he can supply a more satisfactory one. Nevertheless modern discoveries about the material world, true as they may be in other respects, have often been misinterpreted when unlinked to the first principles of our material world.

c. Modern science

Typical modern science does not have the kind of principles we have just been describing. It settles for less than certitude and must sometimes revise its structure because what it thought was first, e.g., the mechanical atom of the nineteenth century, must yield to what is still "more first," e.g., the quantum atom of our own day. *In general, modern science in the concrete seeks causal correlations which express how one thing (the dependent variable) changes when another thing (the independent variable) changes.* A classical example of this is Boyle's law.

Why lay so much emphasis on the definition of science as a certain knowledge in terms of proper causes or reasons since this formulation is not carried out in practice today? The answer is that the earlier classical definition, based on the nature of man the rational animal, provides an ideal toward which our reason aims. It is a model that more than often is only approximated in the concrete. There can be models *for* science, just as there can be models, e.g., the billiard-ball atom, *within* a science. It is not that modern scientists — physicists, chemists, and biologists — have no thrust toward certitude and toward the first principles which assure it. Rather the obscure and complex areas where modern scientists usually work — the invisibly small, the tremendously distant, and the remotely past — put certitude beyond practical reach. Scientists would like it, if they could find it; as a theoretical ideal Aristotle's definition is relevant to an underlying and implicit drive behind even the modern student of nature in his quest for the secrets of matter and of life.

IV. MOBILE OR MATERIAL BEING

The subject of the science of nature may be best designated as mobile or changeable being,[15] with motion or mobile taken in a sense wide enough to include any physical change. If the term mobile being seems awkward, we can call our subject material being.

There are several reasons for considering the subject of physical, natural science to be mobile being or, where the material is taken as the mobile, to be material being.

a. The obvious fact of motion

In the first place, as shown by its Latin root, mobile means that which is capable of being moved. Material once meant the very same thing, i.e., what is capable of motion.[16] *Now the most obvious fact about our universe is its mobile or changeable character, its power to come to be and pass away.* Everything in this world is either in motion or capable of being in motion. Permanent as even the sun and stars appear, they perform a familiar relative motion with respect to the earth; and man himself, the greatest of visible creatures, comes to be and passes away. Listen to the way the poet puts it.

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[15] *Commentary on the Physics,* Bk. I, lès. 1, n. 4; *On Truth,* q. 14, a. 9, reply 16; *Commentary on the Ethics,* Bk. I, les. 1, n. 3; *Commentary on On the Heavens,* Bk. I, les. 1; cf. also, Cajetan, *De Subjecto Naturalis Philosophiae* (Quebec. 1939).

[16] *Commentary on the Physics,* Bk. I, les. 1, n. 3; *Commentary on the Trinity,* q. 2, transl. Sr. Rose Emmanuella Brennan (St. Louis, 1946).

The tusks that clashed in mighty brawls
Of mastodons are billiard balls.

The sword of Charlemagne the Just
Is ferric oxide, known as rust.

The grizzly bear whose potent hug
Was feared by all is now a rug.

Great Caesar's bust is on the shelf,
And I don't feel so well myself.[17]

b. Motion as a test of the reality of the physical world

Second, not only is motion the most obvious fact about our world, but it is motion which awakens us to the reality of that world. *The test of whether a thing is physically real or not is whether it can interact with our own bodies, hurting or helping us in a physical way or responding in some other manner to our sense of touch.*[18] Were it not for motion, there would be no problems for the human intellect. The fact that things in motion are always changing arouses our wonder and provokes the question, *why?*, leading us to seek causes and acquire science.

c. Motion as revealing natures

In the third place, *not only is motion the most universal characteristic of things we experience and the means of awakening us to the reality of our world, it is also our best source of knowledge regarding the things of our experience.*[19] Consider a man sitting on his front porch beside his dog. If, by a farfetched and even impossible hypothesis, some rational observer whose experience had never included contact with either of these creatures should suddenly chance upon them, he could look at them in their static posture for an indefinite time without ever discovering which was the rational animal or whether either one was rational, or for that matter whether either was an animal. But the moment they began to operate — let us say they were each given a problem in arithmetic or set to the task of constructing a home or disposing of the dead — the great difference between the

17 "On the Vanity of Earthly Greatness," by Arthur Guiterman, in *A New Anthology of Modern Poetry*, ed. S. Rodman (New York, 1938), p. 119. Reprinted with the permission of Random House, Inc.

18 D. Armstrong, *Bodily Sensations* (New York, 1962) pp. 28–29; A. Garnett, *The Perceptual Process* (Madison, Wis., 1964), ch. 4.

19 *Summa contra Gentiles,* Bk. II, ch. 1, English translation. *On the Truth of Christian Faith,* transl. J. Anderson (New York, 1956); *Commentary on the Metereology,* Bk. IV, les. 16.

two animals would begin to emerge. Without studying their operations, our hypothetical observer would be unable to decide whether either of the two objects was rational, animal, vegetable, or even mineral. Indeed, until he observed their independent motions, he might even conclude that the two creatures, sitting together, were actually but one thing joined by a subtle medium of some sort.

The various motions or changes in physical things thus reveal to us something about their natures. No one could decide, apart from the motions of physical things, what the various elements and compounds are, whether hydrogen is combustible, and oxygen not; whether silver is a stable element, and radium not; whether heavy bodies and light ones fall at the same rate; whether a compound can be resolved into elements and elements synthesized into compounds; whether like charges repel and unlike charges attract; whether the moon affects the tides; whether in an elastic substance stress is equal to strain; whether carbon dioxide and sunlight are necessary to the green plant; whether radioactive fallout is dangerous; or what the difference is between sickness and health. Motion thus reveals to us the character of the subject which undergoes motion, i.e., the mobile being. Since mobile being is that about which motion enlightens us, mobile being is the subject of our physical or natural science.

V. IMMOBILE BEING, MOBILE BEING, AND METHODOLOGY

In the study of any subject, including material or mobile being, the mind must begin with what is better known and work toward what is less known. This is the fundamental principle of all teaching and all learning. Progress in knowledge is a movement from the familiar world to things that are unfamiliar, from what we know to what we do not know, from what is more intelligible to us to what is less.

a. The least intelligible reality most intelligible to us

In order to expand upon this basic principle of learning, a distinction must be made between things that are more intelligible to us and things that are more intelligible in themselves. *What is most intelligible to us is ordinarily least intelligible in itself, and what is* *least intelligible to us is what is ordinarily most intelligible in itself.*[20] The world around us is more intelligible to us than what is above the physical universe. But this world around us that we find most fitted to our knowing powers and hence most intelligible to us is less intelligible in itself than, say, an angel. God is supremely intelligible in Himself, but to us who in the natural order know Him only by His effects, He is the least intelligible of all things.

b. *We begin with material things*

Progress in human knowledge from the better known to the less known is a movement of the human mind from what is more intelligible to us but less intelligible in itself to what is more intelligible in itself but less intelligible to us. This proposition will govern our divisions of the various sciences into the order in which they are learned. It is a principle that should dominate the whole life of learning. *In the natural order, logic would require that scientific knowledge of the material and mobile world precede the study of what is purely immaterial and immobile.* Until proved otherwise, mobile being is the only kind of separately existing being our mind knows without the aid of revelation.

c. *What part of the material world is best known to us?*

To this question, a number of answers might possibly be given. Some might argue that a science of nature begin with Galileo's experiments on falling bodies. Others, as their textbooks show, would begin with Newton's laws concerning local motion. Still others start with the principle of Archimedes in regard to the lever. Descartes wanted to begin natural science with the study of light.[21] Why not begin our study of nature with the atomic theory or at least with a classification of matter according to the periodic chart? Other points of departure for the study of mobile or material being might be astronomy or even the world of living things, including man himself. All of these considerations appear as possible starting points for the study of material being. Which of them concerns the mobile world in the form that is most intelligible to us? *Which, if any, of these various*

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[20] *Physics,* Bk. I, ch. 1, 184a, 17–21; *Posterior Analytics,* Bk. I, ch. 2, 71b, 34–52a, 6; *Commentary on the Physics,* Bk. I, les. 1, n. 6; *Exposition of the Posterior Analytics,* Bk. I, les. 4, n. 16; *Summa contra Gentiles,* Bk. II, ch. 77; *Commentary on the Ethics,* Bk. I, les. 4, n. 52.

[21] *Discourse on Method,* pt. V, in *Descartes: Philosophical Writings,* ed. N. Kemp Smith (New York, 1952), p. 148.

kinds of motion, can furnish the first principles of material being, the starting points that make it possible to construct a demonstrative science of nature aiming at the ideal of science sketched earlier?

VI. GENERAL AND VAGUE KNOWLEDGE IS EASIER

The answer to our question requires a respect for the order of learning. Granted that the material or mobile must be studied before the immaterial and the immobile, what part of the material and mobile world must be studied first?

In order to reach a decision on this problem and once again going back to the nature of man, *it must be observed that the human intellect works from general notions to particular or specific ones, from vague knowledge to knowledge that is more precise and detailed.*[22] This is the order of intellectual knowledge, and this order in the intellect, where alone science exists, is the only order we are considering. If this is so, then the logical order of our study of the material world, as dictated by the very nature of human intelligence, is to begin with the most general and vague considerations and work toward those that are progressively less general and less vague.

Such an analysis requires proof. Two examples or signs will be presented to support our conclusion, and the conclusion itself will then be shown to follow from a principle that everyone would admit.

a. Proof by common example

A classic example to show that the human intellect begins with general and vague knowledge of any object and works toward more particular, distinct, and precise notions is the case of a man walking down a road and sighting a distant object.[23] At first, he will have only the haziest notions about the visible thing, not knowing perhaps anything at all about it except that it is, like all other matter, a thing. As he approaches closer to what he first recognized as only a thing, our pedestrian begins to recognize more distinct features of the object. If it is moving of itself he will know that it is living. At a still closer approach, our observer will recognize even more precise details, e.g., the animal is a quadruped. As the distance continues to lessen, the person may have enough knowledge to know that the animal is a rodent, and finally, on getting still closer, he

[22] *Commentary on the Physics,* Bk. I, les. 1, n. 7; for modern confirmations of this view, cf. B. Russell, *My Philosophical Development* (New York, 1959), pp. 133, 229; L. van Bertalanffy; *Problems of Life* (New York, 1960), pp. 44–45.

[23] *Commentary on the Physics,* Bk. I, les. 1, n. 9.

will see that what was originally called only a thing or an object is, let us say, a squirrel.

Such is the direction taken by intellectual knowledge. *In knowing material things, there is a growth from universality and vagueness to particularity and precision, and in experiencing any new object for the first time, more general and indistinct ideas about it occur first, followed by more particular, distinct, and precise notions.* Our squirrel may be recognized as a familiar object by anyone who comes upon it suddenly by looking out a window and seeing the animal in his yard or on his porch roof. But if such knowledge is to increase still further, it will move in the direction of more particular detail and concreteness. This is to say that if we wish to know more about the squirrel that appears suddenly before us and is immediately recognized as a definite animal, a squirrel, such an increase in knowledge will involve more about the details of the animal's life until finally it will be necessary to enter the technical world of anatomy and physiology of the organism to continue our knowledge. Increase in knowledge of any material or mobile thing is thus a movement from the relatively more general and vague to the relatively more particular and distinct. A self-conscious science of the material world, built on the nature of human reason, will follow a similar slope.

b. Another example: The behavior of children

As another sign of how the intellect moves from vague knowledge to more perfect notions,[24] *a baby will first tend to call all women by the same name, "mama," because the infant does not have enough distinct knowledge to differentiate one woman from another.* As his knowledge increases, the child will put distinction and differentiation into his notions and in this way will have a greater awareness of the difference between his own mother and other women. In articulating language, children first use nouns and verbs, the most general parts of speech, and only later do they know enough to employ the other parts of speech which are particular and specific refinements of the noun and verb.

c. Proof by principle

A principle can also be invoked to prove our present point.[25] The work of human reason is, in a broad sense, a kind of movement from

[24] *Ibid.*, Bk. I, les. 1, n. 11; cf. also J. Piaget, *The Child's Conception of the World*, transl. J. and A. Tomlinson (Paterson, N. J., 1960), pp. 37, 39 ff.
[25] *Summa Theologiae*, I, q. 85, a. 3.

one thing to another. Like all movement human knowledge about anything reaches its perfection in gradual stages, as our whole educational system from kindergarten through graduate school bears witness. Our intellect proceeds from potency to act. *As a capacity for knowledge it progresses through various intermediary stages in its advance from ignorance toward complete and perfect knowledge. These intermediary stages constitute relatively imperfect, imprecise knowledge.* This is but another way of putting the proposition that, as human knowledge advances, it first grasps those aspects which a thing shares in common with other things, and later on it comes to know those properties peculiar to the reality in question. For the intellect to reach its perfection by gradual stages means to begin with the imprecise notions of things and work to the precise ones. This is the natural direction of our mind in all knowing and a complete science of nature should be constructed accordingly.

d. A possible misunderstanding

It would be naïve to suppose that, upon encountering any object in our experience, there is a distinct moment when our intellect understands its most general characteristics, then a pause followed by a grasp of those characteristics which are slightly less general than the first, until ultimately the intellect seizes those properties which indicate the nature of the object. When the mind's knowledge of a thing increases, there is a growth from the more universal and vague notions to more particular and distinct notions. But ordinarily there is no temporal lapse in a mature mind between recognizing a squirrel in a vague way as an object and recognizing it in a more distinct way as a squirrel. Because of previous experience which has enabled us to form habits of looking at reality, things like sticks or stones or squirrels are recognized immediately to be what they are. *Nevertheless, in any concept we reach concerning material things, a generic knowledge is* **implicitly** *and* **logically** *prior to knowledge that is more particular and distinct.* In other words, as we cultivate the habits which enable us to identify objects of our experience in a fairly distinct and particularized way, the more general and vague notions are formed first, and they remain implicitly or logically first even though we appear to recognize familiar things at once as being what they are, with no time lag involved.

VII. ORDER IN THE STUDY OF NATURE

a. What is first in our science of nature?

If general and hazy notions about material being are implied by the more proper and precise notions, it follows that any attempt to achieve a complete science of nature must begin with universal and vague notions concerning the mobile world. If we are to start at the beginning of our subject, logic requires that the most universal aspects of material reality be analyzed first. The mind, commencing a study of nature in this fashion, begins with the quest for principles like those illustrated earlier in this chapter and thus provides the groundwork for the certain knowledge of things in terms of proper causes, which is science in the best sense of the word.

The appropriate way to erect a total science of nature, sure of itself from the start, is not to begin with the equations for falling bodies or with Newton's laws for local motion. An analysis, scientific in our ideal sense and hence beginning with first principles, will not start with astronomy or atoms or living things. All of these starting points would involve particular principles or particular types of material being. Falling bodies, movements of the stars, or motions in the living world are special or particularized kinds of movement with specialized or particularized principles. *What the mind knows first, and what therefore ought to be first considered by a science patterned on the nature of human reason, is not the special and the particular but what is contained in the general and the vague notions of our material world.* It is at the general and vague level that things are more intelligible to us, and it is here that we will find the first principles of our science of nature, if such principles can be found at all.

Science is a kind of "art" added to our natural intelligence. If our intellect of its own self tends to go from the general and vague to the more particular and more exact, our science of nature should follow a similar order. This means that more general aspects of the material world must be examined first. It means that mobile being in general should be considered before an analysis is made of special kinds of mobile being and special kinds of motion. It means that our first principles or starting points for the study of nature will be the most universal or most generic principles of material things.

Although vague and general notions about the physical world are most readily understood by us, they are not as intrinsically intelligible as those more precise and specific notions which are harder for us to grasp. The refined and distinct knowledge of our world which we gain, for example, in modern biology, is quite difficult. That is why we have argued that the modern sciences, in practice, only approximate our theoretical ideal.

b. Science in its Aristotelian and modern senses

Even though common and hazy notions about the material world are relatively easy to reach, they are by no means trivial and irrelevant. They come at the beginning of our study of nature. They are so easy, as Chapter II will show, that they slip, almost subconsciously, into our mind. Being easy and unobtrusive, they are so much unnoticed that the modern investigator of nature, concentrating on detailed and distinct knowledge, is unaware that these general notions, which are logically prior to any subsequent knowledge of physical reality, exist in his mind; he thus feels able to dispense with such notions and to construct an organized knowledge of nature without them. *But even if they are so easy and so unobtrusive as to escape awareness, they are yet present to the mind prior to (and even within) its more precise notions, and if the are not properly analyzed, serious errors may result in science, not so much in the discovery of fact as in the full interpretation of the fact.*

Probably no knowledge is more important to us than the notions which are common and generic. General knowledge is not ignorance, and vague and hazy notions are not error. On the contrary, our universal notions about nature, vague and common as they are, form our most certain knowledge of the physical world. If, properly analyzed, these notions are not valid, no other notions are trustworthy either. They give meaning to all other knowledge of nature. It is at the general level that our intellect is most at home. As the mind moves to more refined and distinct notions, vagueness gives way to clarity. But at the same time there is a loss of certitude in our knowledge. Modern research into nature, as in the study of atoms and their parts, yields a mine of rich detail, but our certitude has wavered to the point where explanations are only hypothetical and where dialectic often takes the place of demonstration, again taking the classical definition of science as an ideal yardstick.

c. The unity of mobile being as a subject

According to the view proposed here, it would be inaccurate to regard mobile being as open to study by two distinct sciences, one considering it at its general level and the other considering it in a more proper and precise way. Knowledge that begins with general considerations concerning a subject matter naturally tends to become more precise; unless it does so, it remains intrinsically imperfect. *The same science that studies the first principles or ultimate causes in a given order of reality tends, by its intrinsic nature and not by any external force, to complete itself by the study of proximate causes and detailed reasons.* We do not change sciences in moving from a general to a particular level, so long as we do not change subjects. What we do is to change the perfection in our knowledge of the subject; we are like the man who recognized the distant object first as only a thing and later came to the much more perfect knowledge of it as a squirrel. Particular scientific knowledge is more perfect since it is more specific, although, from another angle, it is less perfect since it is less certain. General scientific knowledge is more perfect in being more certain but less perfect in not being distinct knowledge.[26]

VIII. THE GENERAL SCIENCE OF NATURE

a. Context and perspective in knowing nature

Concern with material being at its most general level forms the theme of this book, and, accordingly, it is now possible to understand why we call this book a *science* of nature. *A scientific study of nature in its most general traits, in other words, a study of mobile being in its most universal character, forms our first problem in elaborating a logical and complete science of material things.* The general science of nature, also known as the philosophy of nature or natural philosophy, is logically presumed by studies that we identify as modern natural science even though historically scientists do not study it. Physics, chemistry, and biology, as we know them today, deal with this or that kind of mobile thing — falling bodies, the elements, organisms. These are problems of great interest and of vast importance; but they are not the problems where a truly complete scientific knowledge of nature should logically begin. Material being should be considered at its universal level before funneling downward to a concern with the various kinds of mobile things.

Many thinkers do not agree with this analysis. They would like physics, chemistry, and biology in their modern form to be studied prior to what we have termed the general science of nature; they would make of the general science of mobile being only a synthesis

[26] *Ibid.*, I, q. 14, a. 6; *Physics*, Bk. I, ch. 1, 184b, 24–25; *Commentary on the Physics*, Bk. I, les. 1, n. 7.

of the various special knowledges attained beforehand. Some would even make the whole function of a general science of nature to be an extension of physics, chemistry, biology, and related fields. But this arrangement of subject matter is contrary to the human order of learning. J. Robert Oppenheimer writes,[27] modern science "takes common sense for granted. . . ." It is the area of the physical world first encountered by common sense, and the precondition for all further knowledge, that our general science will analyze.

The general science of nature that Aristotle first evolved does more than merely precede our more exact and detailed knowledge like a drum major leading a parade. It conditions our distinct knowledge. It gives context and perspective to all other natural science of material things. It gives interpretation to mathematical physics. Seen within the horizon of first principles, modern experimental disciplines will be more than the practical knowledge affording a know-how for making television sets, atoms, and space satellites. Science in the modern sense will then be regarded no longer as a mere aesthetic satisfaction but as something of far greater importance. Modern science would then no longer be so powerless before "the fundamental problem left open by scientific method," to quote Henry Margenau.[28] It will no longer have to leave "our feeling of incompleteness unsatisfied," as Erwin Schroedinger[29] has written.

b. Permanence of the general science

Since Aristotle's time, many sweeping changes have taken place in our knowledge of matter. The heliocentric theory of astronomy, as shaped into final form by Kepler, has replaced the geocentric view. Galileo's laws of falling bodies have become accepted formulas. With Newton, a universal mechanics came into being, and a short time later the march of modern chemistry began, leading at the start of the nineteenth century to the now well-established theory of atoms. In biology, great discoveries have been made concerning the structure and function of living things in health and in disease, and probably no modern scientific theory has had such a widespread influence as the evolutionism of Darwin.[30] Even this brief list of exploits brings

[27] *Science and the Common Understanding* (New York, 1953), p. 5.

[28] *The Nature of Physical Reality* (New York, 1950), p. 459.

[29] *Science and the Human Temperament* (New York, 1938), pp. 108–109.

[30] Teilhard de Chardin can provide an invaluable contribution to a so-called complete natural science. But his questions in *The Phenomenon of Man*, transl. B. Wall (New York, 1959), are not the first questions the mind must answer about nature. We must first find out what is here and now, in the spirit of Aristotle, before we can ask with Teilhard how it got this way.

us only to the beginning of our own century when brilliant new accounts of matter emerged in the form of the quantum theory and relativity mechanics. But with all of its undoubted and undying value, science in the modern sense of the term affords knowledge of a special sort concerning nature. It concerns various kinds of motion, not material being in general. It is knowledge gained by the refined techniques of measurement and experimentation. It is so detailed that it is frequently formulated in mathematical equations or in graphs. As earlier indicated, it does not attain first principles.

Though arising out of general experience — by contrast to the specialized experience which we call experiment — our general science is preinstrumental and pre-experimental knowledge simply because it is knowledge of a very general kind. Alfred North Whitehead recognized the need for a study of nature with "a generality transcending any special subject-matter."[31] That would be a good way of characterizing what we have been calling the general science of nature. At the beginning of this general science, all we need is a knowledge of logic and experience of change.

Science in the modern sense of the term depends in great part upon instruments. From the study of the stars to the concern with atoms and their parts, our metrical knowledge of nature has changed as instruments have become more refined and experiment has grown more exact. But since the general science of nature does not depend on measurement and experiment, it could well develop before the rise of modern instruments, and it has survived even though our measuring instruments have furnished new and even revolutionary data in the area of specialized study. Without previous general science, we would not be able to design instruments and arrange experiments to learn more about what we already know in preinstrumental and pre-experimental ways.

Logically prior to and presupposed by refined knowledge through experiment and measurement, the general science of nature is thus immune from the revolutions that have taken place in specialized knowledge.[32] *Our means of attaining this general science are no better and no worse than Aristotle's. They are in fact no different from his. The means is human reason itself, unaided by specialized and mathematical techniques, proceeding only by a logical analysis of general experience,* which our next chapter will explain. Man was a rational animal in ancient Athens and is still so.

[31] *Process and Reality* (New York, 1929), p. 15; cf. also J. Randall, *Aristotle* (New York, 1960), p. 169.

[32] P. Strawson, *Individuals* (New York, 1963), p. xiv.

c. *Certitude of the general science*

As another way of understanding why the revolutions within our specialized knowledge of nature have nevertheless left a general science standing firm, *it should be observed that the universal characteristics of mobile being, since they are most intelligible to us, are relatively easy to grasp and, as most fitted to the human intellect, are strongest in their certitude.* But when we move away from the universal marks of things to more particular and refined characteristics, we enter an area that is less and less intelligible to us, even though in its own intrinsic nature it is more intelligible. As less intelligible to us, such an area is harder to study, and error can more easily enter it. As one means of preventing such error, man uses controlled experiment.

The general science of nature, although in essence it goes back more than two thousand years, is a permanent achievement of the human intellect. Questions raised in this general science more than two millennia ago are still raised by men of today, and they are still answered at the same level of preexperimental study and by the same means. What is motion, time, place, and continuum, etc.? Just what do we mean by these terms anyway? All such questions are at least implicitly raised prior to measurement and experiment. Measurement and experiment do not ask them; nor do they answer them. The realm of those universal principles in nature which are most intelligible to us and prior to all other considerations is usually accepted by the modern researcher in some unanalyzed form. Failure to make a proper analysis of these general notions has led to serious errors in the history of science, e.g., the nineteenth-century's theory of "indivisible atoms."

d. *The concern of general science: Mobile being in general*

As further evidence that a general science of nature should come before special studies of the physical world and also as evidence that the general science is not open to the radical changes which have characterized the more special fields of inquiry, let us go again to the famous case of a falling body. If a modern physicist were pressed to ask what he means by a falling body in order to assure himself that he can define it properly and explain it to someone else, he would no doubt say something to the effect that a falling body is a body in a certain kind of motion. He would affirm, in other words, that it is a certain kind of mobile being. Such an analysis would indicate to us that mobile being is more familiar and more intelligible to us than the kinds of mobile being. The concept of mobile being would be employed to make clear and intelligible to someone else what we mean by a falling body; in other words, it would be assumed in explaining what is meant by a falling body that an inquirer knew what is meant by material or mobile being. The modern scientist can no more conceive a falling body without conceiving mobile being in general than a man can think of a squirrel without thinking of an object or thing. For a complete[33] science of nature that goes back to first principles it would only be logical to analyze mobile or material being in general, because the concept of mobile being in its universal traits is implicitly and logically presupposed by a science of the various kinds of mobile being. The general knowledge of mobile being requires special and proper knowledge to complete itself and special or proper knowledge needs general science to examine its presuppositions.

The full study of falling bodies, we have just seen, requires a study of mobile or material being at its most general level. The same analysis of mobile being in general would have to precede the resolution of any more particular problem such as local motion in a straight line, the combinations of atoms and molecules, nutrition and growth and reproduction among living things.[34] Rectilinear uniform motion of the sort studied by Newton, the behavior of molecules, atoms, and their parts as studied in chemistry and physics, and all the life processes studied in biology are special kinds of motion of special types of material being. But in order to represent such special types, the concept of mobile being in general is logically implied and logically prior, and as such, must be brought out into open analysis if a complete science of nature is to be attained.

In order to avoid useless repetition in the analysis of types of mobile being, it is fitting that there be a portion of our study of nature devoted to a study of material being in general.[35] To such a study Aristotle devoted a whole work called the *Physics,* and to a similar task all the rest of the present book will be directed. We may not agree with all of Aristotle's answers in the *Physics.* But his questions are still meaningful. Man is still the rational animal.

[33] But by complete we mean here something akin to being a whole and not a system that can account for every detail of nature as a whole or of any single thing in nature.

[34] However, a distinction should be made between the way in which mathematical physics is related to a complete natural science and the way in which biology, say, is so related. See my *Science and Philosophy* (Milwaukee, 1965), ch. VII.

[35] *Commentary on the Physics,* Bk. I, les. 1, n. 4.

CHAPTER II

THE FIRST PRINCIPLES OF NATURE

I. CHARACTERISTICS OF FIRST PRINCIPLES

A knowledge of nature, scientific in the sense of our first chapter, requires first principles, and there is evidence that our quest for such principles should begin at the level where knowledge is vague and general. As the ultimate sources or origins of all material being, the first principles in nature must have three characteristics that are of special importance. They must be known with certitude; they must be universal; and they must be physical rather than mathematical or metaphysical in character.

a. *First principles must be certain*

Principles known only hypothetically cannot furnish the real foundations of science in its perfect form. Known only in a provisional way, they cannot put into our knowledge that certitude[1] which alone can satisfy the mind in demands that are built into human nature.

Cosmogony, relativity theory, and quantum mechanics, whatever be their place in the hierarchy of human knowledge, cannot, as provisional explanations of things, yield a complete science of nature. Such theories fall short of certitude. They have no analogue to the unit which affords the ultimate certainty in our study of number and thus makes arithmetic a science in an ideal sense.

b. *First principles must be universal*

If certitude is at its maximum in our knowledge of nature only when, as previously shown, that knowledge remains vague and general, it might already be suspected that the first principles we are looking for must also be common or universal.

[1] *On Truth,* q. 11, a. 1, reply 13; q. 11, a. 1, reply 17; q. 12, a. 1.

There are two reasons why the first principles of nature must be the most general and universal principles of material being. The first reason is that the science of nature purports to explain all material beings and hence its amplitude extends to every material being in the world. Since the explanatory principles we are seeking must apply to all motion, they must be the most universal or general principles in all of nature.[2]

In the second place, the first principles of nature will be universal principles because the very first scientific problem in nature as we know it concerns mobile being in general rather than this or that species of motion.[3] As observed in our first chapter, the concept of mobile being, taken simply, is logically prior to the conception of any particular kind of material thing, and mobile being in general must accordingly be studied before the analysis of various species of material things. The principles of material being considered at a general level will be principles that are themselves general or universal.

c. *Our first principles must be physical*

First principles in the general science of nature must not only be certain and universal, they must also, and above all, be physical principles. Physical should be contrasted with mathematical and metaphysical.

The first principles for explaining material being must not be metaphysical since the mind, beginning its study of nature, is as yet unaware that there is any metaphysical object, an object not dependent on matter for its existence. Hence it cannot invoke a metaphysical kind of reality to explain the physical world at the outset of its study. At this point it must be strongly emphasized that physical is a synonym for natural, at least according to the terminology of this book. "Physical" comes from the Greek and "natural" from the Latin, and both of them in their origins meant having to do with birth or coming-to-be.[4] More of this meaning will be seen in Chapter III, but for the present the physical or natural world should be understood as the world of coming-to-be, the world of mobile being. If physical and natural have the same meaning, it is possible to add to them a third synonymous term, the mobile. The physical or natural is the mobile.[5] Since the metaphysical is independent of matter and motion,

[2] *Commentary on the Physics,* Bk. I, les. 2, n. 12.
[3] Cf. *supra,* p. 15.
[4] A. Taylor, *Aristotle* (New York, 1955), p. 63.
[5] *Ibid.;* cf. the definition of nature in ch. III.

it is beyond the mobile, and metaphysical principles cannot be used for demonstrations in the science of nature or mobile being.

According to this analysis, a physical, as contrasted to metaphysical or mathematical, explanation will be an account of material or mobile things precisely as they are mobile beings. Mathematics approaches the world not in terms of motion but in terms of quantity. Although mathematical principles may supply knowledge later on in the science of nature when knowledge becomes more exact and detailed, the initial principles to explain nature must be strictly physical. The reasons for this view are several:

1. In the first place, strictly natural science is an attempt to account for mobile being, and what is most characteristic of mobile being is not quantity but motion.

2. Moreover, at the beginning of our science where mobile being in general is being analyzed, our knowledge is so vague that we are unable to consider the more precise and mathematical properties which flow from mobile being. Notions obtained through mathematical physics, as more detailed knowledge, must come after the general science of nature in a synthetic world outlook developed according to the nature of man, the rational animal.

Knowledge in terms of mathematics is always more or less distinct and exact and hence is not the kind of knowledge enjoyed at the origins of our science where the object is vague and general.

3. Finally, unless there is a physical analysis of nature preceding more particular and detailed knowledge obtained by measurement, the mind is unable to identify what it is that is being measured.

It should be noted that the use of mathematical techniques in the study of matter is not here being repudiated. Far from it; in fact, most of our detailed knowledge of nature will be obtained by mathematical means. *What is being proposed here is that our initial knowledge in the general science of nature must be strictly physical rather than mathematical in character.* Our general science must explain mobile being as mobile and not as just quantified. If metaphysical principles are necessary to explain our world, the need for such non-physical principles will have to be demonstrated.

II. DIALECTIC AND INDUCTION

a. Inductions are not blind

First principles in natural science must be universal because they are first, and they must be physical principles, i.e., principles of motion, because it is the physical, natural, or mobile world that we are trying to explain. They must be known with certitude if science in its more perfect form is attainable.

But what is to be our method for seeking such first principles? Because natural science needs them in order to get started, they cannot be reached by using natural science. In other words, as presupposed by any demonstration in natural science, they cannot be demonstrated within this science. If the first principles were learned from metaphysics or natural theology, this would mean that the mind, beginning a study of the physical world, would already know metaphysics; such a mind would have to know immobile and immaterial things before having a science of the mobile and material world.

Incapable of being previously established by any other science and incapable of being demonstrated in the science of nature itself, our first principles of material being can be known only by induction.[6] Induction is a passage from particular to universal propositions without going through a middle term. The product of our induction will be a proposition whose subject and predicate are immediately, i.e., without a medium, connected with each other.[7]

As is usual in cases of induction, the human mind dealing with the first principles of nature will not at once see the necessary connection between the subject and predicate. What may be called self-evident in the sense of not needing a middle term may nevertheless not be self-evident to us. *In short, a careful investigation must be made in order to reach our first principles of nature and to make what in reality is immediately connected fully evident to us.* This investigation, preliminary to determining possible starting points in our science, is called dialectic.[8]

b. Dialectic, the logical preliminary of induction

As we know from logic, the inductions made in any science do not take place haphazardly and without a preliminary plan. *The discovery by Walter Reed that yellow fever is carried by a mosquito was preceded by dialectical reasoning in which certain questions were asked and various answers drawn out in order to be compared by*

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[6] *Commentary on the Physics,* Bk. VIII, les. 3, n. 994.

[7] *On Truth,* q. 14, a. 1.

[8] Aristotle speaks of dialectic as "line of inquiry," in the *Topics,* Bk. I, ch. 1, 100a, 18; cf. my treatment of dialectic in *The Elements of Logic* (Milwaukee, 1957), chs. 23, 28, 29, 30; also L. Stebbing, *Logic in Practice,* 4th ed. (London, 1954); J. Randall, *Aristotle* (New York, 1960), ch. 3.

induction with experimental evidence. Such a preinductive process of raising questions and deducing the consequences of answering them in both affirmative and negative form is called dialectic. Reed, for instance, knew before he began his famous experiment concerning yellow fever that he did not have to look for the cause of the disease in sea water, the structure of palm trees, the frequency of rain, and the brilliance of sea shells. If any of these factors caused the yellow fever, he could have reasoned, then the disease would occur wherever there is sea water, palm trees, rain, or bright shells. Since there is no inductively observed relation between these things and yellow fever, Reed could have ruled out all of these possible causes; and after many other questions had been raised and answered, he could have hit upon two conclusions worth testing: either yellow fever is communicated by contact with present victims through discharges from their bodies, etc., or else it is carried from person to person by a mosquito. Having reached these dialectical conclusions, Reed could check them inductively by experimental means. A person isolated from all yellow-fever victims and their discharges except for being bitten by a mosquito that had bitten a yellow-fever patient contracted the sickness. Others who made all sorts of contact with yellow-fever victims but were kept away from the suspected mosquito did not fall prey to the disease.[9]

Let us analyze the two dimensions in Reed's experiment; and in order to simplify the task, let us look at the last stages of his reasoning where the two testable alternatives were presented him. He could formulate his two conclusions in the following manner: If yellow fever is carried by a mosquito, then a person bitten by such a mosquito which has previously bitten a victim will contract the disease. Reed's second conclusion would run: If yellow fever is transmitted by contact, then a person who makes physical contact with a fever victim will contract the disease. Up to this point, both of these conclusions were purely dialectical. They are consequences deduced from the twofold question: Is yellow fever carried by a mosquito or by physical contact?

The experiment subsequent to the conclusions is the other dimension in Reed's work. This experimental phase is induction, or the passage of the mind from particular cases to a universal notion concerning all cases of the same kind.

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[9] For a popular account of the experiment, cf. P. de Kruif, *Microbe Hunters* (New York, 1926), pp. 311–333.

c. *The nature of dialectic*

Now the questions we raise and the consequences we deduce from various possible answers to our questions are not in themselves propositions about the real world.[10] They do not become propositions about the real until the consequences are tested by induction. Until this induction takes place, dialectical propositions are provable only; by the subsequent induction they are proved.

The proposition, yellow fever is carried by mosquitoes, expresses a fact about the real world. By contrast to such a proposition, a question and the consequences drawn out of it leave the mind only in the logical order. A proposition about reality is secured when, leaving the dialectical or logical level, we go to physical things and make an inductive test to see which consequence fits observed fact.

Demonstration deals with propositions about real causes and real effects. Dialectical reasoning, as such, deals only with logical beings.

Dialectic is a logic of questioning. A dialectician proposes possible answers to the questions he raises about any subject proposed to him. He then works out the consequences that follow from answering each question in an affirmative or negative way. This is all preliminary to experiential test. Dialectic is a logic of the provable. In contrast to the dialectical questioning that precedes it, induction is an operation of a quite different sort. It puts the mind in correspondence with the real. True induction is knowledge of things, not just of logical entities.

No induction in the learned world proceeds without a dialectical plan to guide it. In all such cases, induction affords a proof of the propositions that are finally accepted by the mind. To the extent that an investigator is still engaged in the dialectic preliminary to induction, his conclusions are provable but not yet proved. If the quest for nature's first principles is inductive because the principles cannot be demonstrated without using them, our induction to the principles must nevertheless be prefaced by a suitable dialectic. However, the dialectic yields only provable conclusions, which can be known to be certain only by a later induction.

III. SOME GENERAL CASES OF DIALECTIC

a. *Art as a dialectical model*

Dialectic is a common operation in the sciences, where suppositions are formulated prior to inductions and where testable consequences

[10] *Commentary on the Metaphysics of Aristotle,* Bk. IV, les. 4, n. 574; Bk. II, les. 3, n. 2204, transl. J. Rowan (Chicago, 1961).

are then deduced; induction is thus usually a test of an hypothesis, rather than the initial stage of investigation. The modern scientist uses sophisticated dialectical schemes, such as the theories of subatomic particles, the double-helix model of the genetic code in molecular biology, and the "big bang" theory in cosmogony where it is held that our universe originated from the explosion of a densely packed primeval atom. But when the mind is first approaching a methodical analysis of nature, no such sophisticated models can be employed. The dialectical schemes here must necessarily be of a cruder type; the materials of such schemes must be the common, ordinary, familiar things best known to us. Aiming at that general science of nature which must necessarily be built on common experience rather than on the specialized experience we call experiment and which must be formulated in ordinary language rather than in the mathematical symbolisms, the dialectician will find several fields within which he can construct models preparing the way for induction to nature's first principles.

One of these is certainly the field of art, like sculpture or the making of tools.[11] *The mind has such a perfect understanding of a statue or a knife that it can bring them into existence. Here then is truly a familiar world from which the mind may try to enter into nature.* We are starting with what we know best, namely the products of our own deliberate planning.

b. Language

Another rich region for dialectical models preparatory to the basic inductions concerning nature is language itself. *Because our language serves us so well in communicating with each other concerning the physical world, there is a prejudice that to some extent a general correlation exists between the structure of our language and the structure of the things that language eventually concerns.* The difference between a noun and a verb indicates some kind of distinction in things. A study of tense in grammar can aid in the understanding of time itself. If language is taken in its widest sense to include the whole of logic, the ten categories will help us to an understanding of the ten kinds of beings which they indicate to us. In moving from logical or linguistic considerations to inductions concerning physical things, the mind is in general proceeding from signs to what signs

[11] Cf. the example of the making of a statue in the *Physics*, Bk. I, ch. 7, 191a 8–10; *Commentary on the Physics*, Bk. I, les. 12, nn. 108–109.

signify. Many present-day philosophers think it is a valuable philosophical task to analyze "ordinary language."[12]

It would be a serious mistake to assume a literal correspondence between our making of a statue and nature's making of anything, say an animal or sunlight; and it would be equally a disaster to seek in language an exact image of the structure of things. Such points of view would confuse a dialectical instrument with a real structure; they would identify the dialectical preliminary of induction with induction itself; they would conceive of our physical world entirely in man's own image and likeness. But there is an alternative between the scrapping of all dialectic on the one hand and on the other hand the mistaking of a dialectical instrument for reality itself and hence the confusion of dialectic with science. This alternative consists in using dialectic with a view to correcting it when necessary and getting rid of it when it has served its function. It is a device preliminary and extrinsic to perfect science.

When we are beginning our search for nature's first principles, there is no more obvious area to address than the things we know well enough to make and to use, our works of art. From them we may get not a replica of nature but at least some clues that can be pursued through our plan of inquiry. Art, mechanical or linguistic, may not provide inductive answers to our basic questions, but it will at least, like a good dialectical instrument, help us shape the questions themselves. Art in any form can never serve theoretical science except as an instrument.

c. Received opinion

A third basic source of a dialectician's raw material is made up of the various common opinions among men concerning the subject being investigated. These are provable propositions until elaborated to the point where it is possible to check them by induction. *Opinions are questions or contexts for questions.* The search for truth is a collective enterprise in which one generation teaches the next and in which even the errors of others, by showing us what to avoid, can be a source of profit. Reason, using dialectic, will be eager to consider the opinions of others in order to draw out their consequences, test their merits, and assimilate whatever truth may be found.

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[12] Cf. V. Chappell, ed., *Ordinary Language* (Englewood Cliffs, N. J., 1964); with special application to our problem, cf. S. Toulmin, *Philosophy of Science* (New York, 1960).

Thus Aristotle, after proposing the requirements for the first principles in nature, turned to his predecessors and contemporaries to examine whether they had met such requirements and found such principles. He wanted to find what truth each set of opinions contained. He wanted to pit his own position against challenge and contradiction in order to strengthen it when possible and to change it when necessary. He thus undertook an exposition and criticism of Parmenides and Melissus, of Anaxagoras and Anaximander, of Anaximenes and Plato, of Thales and Heraclitus. All of these men propounded views on the natural universe; Aristotle deduced the consequences of each view and submitted each consequence to inductive check.[13] By examining the views of his predecessors and testing them inductively, Aristotle thought himself able to discover the truth contained in such views, to avoid fruitless paths of investigation, and to push the inquiry into nature's first principles further.

IV. ARISTOTLE'S DIALECTICAL PLAN OF INQUIRY

a. Aristotle and the modern dialectician

> The principles [of nature] in question must be either (a) one or (b) more than one.
>
> If (a) one, it must be either (i) motionless, as Parmenides and Melissus assert, or (ii) in motion, as the physicists hold, some declaring air to be the first principle, others water.
>
> If (b) more than one, then either (i) a finite or (ii) an infinite plurality. If (i) finite (but more than one), then either two or three or four or some other number. If (ii) infinite, then either, as Democritus believed, one in kind, but differing in shape or form; or different in kind and even contrary.

This is the opening passage of the highly important section in his *Physics*[14] where Aristotle sets out to find the first principles of nature. We have much to learn from Aristotle here, not by merely repeating him but by attempting to live with him in an analysis based on common experience and common logic. Even if he had had our modern instruments and mathematical techniques he could not have used them in the present context; the knowledge he was seeking in his *Physics* was pre-instrumental and pre-mathematical where his equipment was no worse (or no better) than ours — reason turned on common experience. The quotation is given above not with a view to making a close analysis of its contents but only as an example of

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[13] *Physics*, Bk. I, chs. 2–4.
[14] *Physics*, Bk. I, ch. 2, 184b, 15–22.

Aristotle's method. Aristotle follows up the division we have cited by analyzing all of the alternatives he mentions. He draws out, like a good dialectician, the consequences of each position until he reaches propositions that can be checked inductively,[15] and in this fashion, he finally claims to reach the genuine first principles of nature that we ourselves will begin to search out in the present chapter.

Before beginning the dialectical syllogisms and the subsequent induction to nature's first principles, it might be useful to compare the passage we have quoted with the work of science in its modern sense.

As exemplified by Newton and as explained by Einstein[16] and Philip Frank, the "work of the [modern] scientist consists of three parts:

"1. Setting up principles.

"2. Making logical conclusions from these principles in order to derive observable facts about them.

"3. Experimental checking of these observable facts."[17]

Because he is working at a general rather than special level, Aristotle uses common experience rather than deliberate experiment in the post-dialectical and inductive check of his work.

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b. Rigorous logic is possible at this point

The first thing to be noted about Aristotle's outline is the rigorous character of each division. He is not employing a so-called "cut-and-try" method, like that begun by Kepler and continued through the rest of modern physics. In the opening statement of our quoted passage, it is claimed that the principles of nature are one or more than one. Such a division is complete; and the members are opposed to each other in an exclusive way. *Anyone possessing the liberal art of logic, which the general science of nature presupposes,*[18] *could make and follow this division.* So also in the case of the various subdivisions.

What does Aristotle do with the various alternatives he proposes? Let us consider only the first one (a, i), namely, that the principle of nature is one and motionless as held by Parmenides and Melissus. If this is true, Aristotle argues in his dialectic, there would be no

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[15] It would be hard to find a better introduction to dialectic than J. Dewey's "Analysis of a complete act of thought," in *How We Think* (Boston, 1910), p. 68 ff, esp. p. 72.

[16] "Autobiographical Notes," in *Albert Einstein—Philosopher Scientist*, ed. P. Schilpp (Evanston, Ill., 1949), pp. 11–12.

[17] *The Philosophy of Science* (Englewood Cliffs, N. J., 1957), p. 43.

[18] *Commentary on the Ethics*, Bk. VI, les. 7; *Book of Causes*, les. 1.

motion; for motion always involves at least two principles, the old and the new. In the dialectical argument just summarized, Aristotle thus draws out the views of Parmenides and Melissus (a, i) until he reaches the dialectical conclusion that motion, on their supposition, does not occur. But the inductive check of this conclusion reveals that motion does occur. Hence, the conclusion reached from the supposition in (a, i), namely, that the principle of nature is one and motionless, is false; therefore the premise leading to it must be false also. Hence, the first possibility, i.e., that the principle of motion is one and motionless, is eliminated.

Aristotle then continues through his list until, according to his claim, he concludes dialectically and establishes inductively that there are three and only three principles in material things. We are going to pick up his tracks again later in this chapter and try to follow him to the positive conclusion he reaches concerning nature's principles; but since space will not permit a reconstruction of the whole argument based upon the above quotation from the *Physics,* it would be a valuable private exercise to make a dialectical development and an inductive test of all the possible alternatives mentioned by Aristotle. And it would certainly be most instructive to read Aristotle's own dialectic[19] or to follow it in St. Thomas' *Commentary.*[20]

c. Aristotle and the modern cut-and-try method

The simple and certain procedure exemplified by Aristotle in quest of the first principles of nature is seldom possible in human thought. Aristotle was working on a kind of reality that can be experienced head-on, that is open to direct observation, and that all further investigation presupposes. At the outset of his examination, the student of material being can have a deliberate and carefully prepared plan like that which Aristotle preached and practiced; *many other discoveries in the physical universe, however, are based on hunches, and conjectures, since the subject matter under investigation is not open to direct view and since conclusions cannot be checked by sufficiently evident inductions.* In order to gain truly distinct and particular knowledge of such subject matter, it is thus necessary to use a "cut-and-try" method popular since Kepler — conceiving any hypothesis, deducing its consequences, and testing the results inductively; and if the hypothesis fails, a new one is conceived and the dialectical deductions are started all over again until a theory is established as being provable. The proof, however, is inductive.

19 Bk. I, chs. 3–4.

20 Bk. I, les. 2–9.

V. CONTRARIETY OF NATURE'S PRINCIPLES

a. Intimation of contrariety

In going through his file of opinions to screen out the truth in any or all of them, Aristotle claimed that the ancients who investigated the mobile world in a truly physical or natural way agreed that there are contraries in nature.[21] A similar verdict can be reached concerning "received opinion" from modern studies of the mobile world. All successful theories about matter recognize that motion always involves some kind of opposites which, in the broad sense of the word at least, are contrary differences. In chemistry, for example, an opposition or difference is posited between atoms and the spaces between them. In electricity, there is positive and negative charge; in magnetism, the north and south poles are apparent; in elastic substances, stress is opposed to strain. Moreover, an elementary understanding of energy requires the distinction between the opposites, mass and velocity; force is also resolved into two components, mass and acceleration. In optics, the color of a substance depends on the distinction between what is reflected and what is absorbed.

Such a catalog could be continued into the more complicated systems of quantum mechanics and relativity theory. *Here also careful students of nature will be found to agree, implicitly at least, that motion involves opposition, difference, duality. In more technical language, motion involves contrariety.*

b. The definition of contrariety

Contrariety is a technical notion drawn from logic, which the methodical analysis of nature presupposes. Our quest for nature's first principles, as a dialectical enterprise, begins in the logical order. Using "received opinions," even those of modern science, as a dialectical structure, the mind reaches the tentative conclusion that the first principles of nature must be contraries, and induction must put this dialectical conclusion to a real test. But what do we mean by contrary?

Things contrary to each other are, in the first place, different from each other. But contrariety says more than what we ordinarily mean by difference. *Contraries are differences within the same genus.*[22] Blue and red, differences within the genus of the colored, are con-

[21] *Physics*, Bk. I, ch. 5, 188a, 18–19.

[22] *Commentary on the Physics*, Bk. I. les. 5, n. 77; *Commentary on the Metaphysics*, Bk. I, les. 10, n. 2123. For secondary literature, cf. J. Anton, *Aristotle's Theory of Contrariety* (New York, 1957).

traries; being in Baltimore and being in Washington, differences within the genus of where, are likewise contraries. But blue and being in Baltimore are not contraries. Though opposites, they are not in the same genus; they are unrelated by anything save an accidental connection.

c. The inductive test of a dialectical conclusion

It is a matter of common observation that motion involves contrariety. First of all, it requires differences or, as Plato put it, duality. Compared to what or where or how a thing was at the start of a motion, it is different at the end. Induction shows that this is so.

Experience also reveals that the differences which motion involves are contrary differences. This is a certain truth established by induction. Motion in the physical world is not a random, haphazard affair. There is an order in motion, which the mind discovers through induction. That is, there is a certain limit to what this or that thing can become because not everything can come from anything.[23] Although the blue can become the red, and what is in Washington can become present in Baltimore, the red cannot change to being in Washington or the blue to presence in Baltimore.[24]

Of course a man, going from Washington to Baltimore in midsummer, may become sunburned along the way. But there are two motions involved here, and the connection between them is accidental. One motion — from being in Washington to being in Baltimore — is local motion; the other movement — from being not red to being red — is in the order of the qualified. The two motions are related in only an accidental fashion; were there an essential relation between going to Baltimore and becoming red, everyone traveling to Baltimore would become red. Each of the two accidentally related motions has its own set of contraries within the respective genus in which the change occurs, the where and the qualified.

What things may become, as a result of motion, is limited to differences within that genus or category where change occurs. Such differences within the same genus are contraries.

VI. FIRST PRINCIPLES ARE FIRST CONTRARIES

a. Substantial and accidental change

The first principles of mobile being are not just any kind of contraries, like red and blue or like being in Baltimore and being in

[23] *Physics,* Bk. I, ch. 5, 188a, 33–35; *Commentary on the Physics,* Bk. I, les. 9, n. 62.

[24] *Summa contra Gentiles,* Bk. II, ch. 31; *On Truth,* q. 8, a. 3.

Washington. If there truly are first principles, they must be first contraries, i.e., contraries which are not derived from other contraries. In search of such contraries, it is necessary in the first place to insist on the essential difference between substantial change and accidental change and hence on the essential difference in their contraries. *In substantial change, a whole mobile or material being is changed into another mobile being; in accidental change, a material thing remains essentially what it was but is changed according to some modifications like quality, quantity, or place.*

Examples of substantial change would be the burning of wood which yields (among other things) ashes, the death of an animal which leaves only inanimate chemicals, and the weathering of iron which produces a new kind of thing called rust. Accidental changes, by comparison, would be the growth of an animal with the animal remaining the same throughout the process or the transportation of the same wood or same iron from one place to another. The first kind of change is fundamental and the second is only superficial. We could employ the terms fundamental change in place of substantial change and superficial change in place of accidental change. But substance and accident are old categories in our Western tradition and are known to us also from logic.[25] So with the understanding that the substantial is the fundamental and the accidental the superficial, we can continue to contrast substantial and accidental change.

In substantial change, a whole thing changes, whereas in accidental change the thing in question remains itself and simply takes on a new attribute.

Since accidents depend on substance, the contraries in accidental change are dependent and hence derived principles; on the other hand, the contraries in substantial change will be the underived and hence first principles sufficient to make possible a science of nature.[26] If substantial change takes place, the contraries which it involves, corresponding to the blue and the red in the qualified, will be the principles in nature from which everything natural is derived and which themselves are not derived within nature.

Substantial change is here contrasted with accidental change, and it is being argued that the contraries in substance, the first genus, are first contraries in mobile being and hence the first principles of

[25] As is well known, Aristotle wrote a book called the *Categories*, in which he studies what men mean by the ten supreme kinds of predicates he finds represented in their speech. For a modern rethinking of categories, see G. Ryle, *The Concept of Mind* (New York, 1949), p. 18 ff.

[26] *Commentary on the Physics*, Bk. I, les. 11, n. 85.

nature. There might, however, be room to argue that the distinction we are now making between changes according to substance and changes according to accident is really out of place at this general level of investigation,[27] that it depends on the findings of modern physics and chemistry, and that it should therefore be put off until a later stage of our inquiry. To discuss substantial change, is it not necessary to consult atomic physics with its theories of subatomic particles, binding energies, fission and fusion, etc.?

In answer to this objection, it should be emphasized first that our present concern is only to show that there is a difference between substantial and accidental change, not to explore what this difference is in the clear and particular manner made possible by modern physics and chemistry.

Second, a realization of the difference between the two changes in question is a matter of general knowledge. The distinction between substantial and accidental coming-to-be is basic in our study of nature and is presupposed to any further knowledge of motion and of mobile being. The mind, even in its vague and general notions of the physical world, thinks that there is an essential difference between, say, the burning of wood and wood's change of position, between the growth of a cat and the death of a cat, between the reddening of an apple and the digestion of an apple in some animal or other. The mind, let us repeat, naturally sees an essential distinction between substantial and accidental changes. And it sees this distinction quite early in any analysis of nature, where it is most sure of itself. This distinction is known by induction.

Third, since all our knowledge of nature is derived from change, the distinction between substantial and accidental change is the basis for that distinction, so important in all further knowledge, between what is essential and what is non-essential to the things that we experience. How do we get our first vague inklings of what is essential and what is non-essential to wood except to see how far the wood can be altered without ceasing to be wood? The first general knowledge of what is essentially living as opposed to non-living occurs when living things no longer change in mere size or color or position but when they die. The difference between what is essential and what is non-essential to the things of our experience, e.g., wood, cats, iron, etc., is in its final analysis a matter of distinguishing between substan-

[27] Actually the determination of the *properties* of primary matter belong to metaphysics. The general science of nature establishes the *existence* of primary matter by induction; *Commentary on the Physics,* Bk. I, les. 12, n. 107.

tial and accidental change; that is why this distinction can and must be made quite early in our study of nature and not in the particular and specialized branches of our science which depend on the distinction between the essential and non-essential. Even to ask whether this or that change, as studied in atomic physics, is fundamental to a thing or merely a superficial modification, shows that the human mind, prior to knowing about atoms, recognizes an area of fundamental or substantial change by contrast to superficial or accidental modifications.

Fourth, language shows that we think of some things, e.g., wood, paper, or living realities, as coming-to-be and passing away (substantial change) in contrast to things that remain what they are and simply acquire a new attribute like a new shape or size (accidental change). Thus the difference between substantial and accidental change is a basic distinction in our common language where our first thoughts about nature are embedded.

It may be that our dialectical defense of the distinction between substantial and accidental change seems unduly complicated. It is not the initial knowledge of this distinction which is complicated but rather any attempt to define and defend anything so fundamental. The complexity is on the part of our dialectic; not on the part of the distinction which the dialectic is upholding.

Substance is the first and fundamental mobile being in our world, and contraries in changes that take place within this genus are the first and fundamental contraries. In contrast to the derived and dependent contraries in accidental change, contraries that substance embodies can be best designated as possession (*habitus*) and privation.[28] These are contraries only in a wide sense of the word,[29] and by an extension of the meaning of contrariety as found among accidents, e.g., red and blue or hard and soft. Possession and privation, as opposites in the genus of substance, contraries in the wide sense of the term, and first principles of mobile being, must now be explained.

b. The contraries in substantial change

Privation should be set in contrast first of all with negation. Negation is any absence of an attribute, e.g., the absence of sight (blindness) in the case of a stone. Privation, on the other hand, means something more. It designates the lack of a quality in a subject capable of

[28] *Commentary on the Physics,* Bk. I, les. 10, n. 81; *Commentary on the Metaphysics,* Bk. VIII, les. 6.

[29] John of St. Thomas, *Curs. Phil., Phil. Nat.,* P. I, Q. II, art. 1, ed. B. Reiser (Turin, 1933), II, 43 ff.

owning that quality.[30] Thus, the lack of sight, a simple negation in the case of a stone, is a privation for man or a dog or a horse. Privation is a negation of something in a subject competent to have that something.

Privation and possession (*habitus*) are the fundamental kinds of opposites. Contraries only in a wide sense of the word, they might be better presented as principles of contrariety[31] since they form the basic opposition which exists in nature. *As opposites within every substantial change, possession and privation, in the changes of material substance, are two fundamental principles in our mobile world.* Rusted iron possesses a certain character that the natural world was deprived of before. The remains of a dog has (possession) a reality that before it did not have (privation). What formerly was wood (possession) is no longer wood after burning or rotting (privation). In all such changes, a thing does not change only according to one or more of its attributes; but the whole thing changes and the change itself involves the opposition between a possession and a privation.

So far in our dialectical quest for principles, it has been shown that all careful students of nature have remarked on the differences or oppositions found in all motion. But many of them, including modern natural scientists, fail (understandably) to go all the way to the first differences or first contraries which are revealed by substantial change[32] and which may be described for the moment as privation and possession. This is a principal way in which Aristotle's concept of natural science differs from that practiced by the modern student of nature.

VII. THE SUBJECT OF THE FIRST CONTRARIES

a. Accidental change requires a subject

Our discussion has taken a short cut through the outline quoted from Aristotle earlier in this chapter, and the conclusion has been reached that the first principles of material being are at least two: possession and privation in the substantial order. Every motion in the accidental order requires contraries, and since accidents depend on substance, all mobile being depends upon possession and privation in the sub-

30 For various meanings of the term *privation*, cf. *Commentary on the Metaphysics*, Bk. V, les. 20, nn. 1070–1073; Bk. IX, les. 1, n. 1785; *On the Power of God*, q. 9, a. 7, reply 11.

31 *Commentary on the Metaphysics*, Bk. X, les. 6, n. 2036 ff.

32 *Physics*, Bk. I, ch. 5, 188b, 30–33; *Commentary on the Physics*, Bk. I, les. 10, n. 80.

stantial order. These opposites, because they are in the substantial order, are first contraries even though contrariety is used here in a wide sense of the word. Such first contraries are first principles of mobile being.

But contraries, whether secondary as in the case of accidental modification, or primary as in the case of substantial change, are not enough to account for motion. There must be a subject competent to possess at the end of the process what it lacked before (privation).[33] A look again at some common examples will supply inductive evidence for this conclusion. In changes of color, like that of an apple, greenness does not become redness, and in our example of local motion between Baltimore and Washington, one place does not become another. That which was green becomes that which is red; a man, e.g., who was in Baltimore is now a man who is in Washington. *As shown by these examples, contraries in motion require a common subject in which they succeed each other.*

b. Substantial change requires a first subject

Even in the case of substantial change, possession and privation, which are first contraries and first principles in nature, require a subject. For like contraries in the accidental order, possession and privation in the substantial order can succeed each other, as they do, only if there is a common subject. *If nothing from the old substance abided in the new, annihilation and creation would occur.*

Using from our logic the notion of contraries,[34] our analysis had led to the induction that motion always involves a subject and two contraries; in the substantial order this first subject is called primary matter, and the two first contraries are possession and privation. Primary matter and two contraries which are all evident in substantial change are the three first principles of mobile being, underived in nature and the physical source of everything in our physical world.

Our argument, following Aristotle's alternatives at the beginning of this chapter, could go on to show the inductive conclusion that no change essentially involves more than one subject and more than two contraries and that there are not more than three first principles in nature. If there were more than one subject or more than two contraries, there would be more than one change, as in the case of the man going from Washington to Baltimore and becoming sunburned along the way.

[33] *Physics*, Bk. I, ch. 6, 189a, 34–189b, 15; *Commentary on the Physics*, Bk. I, les. 11 (*passim*); *On the Power of God*, q. 3, a. 2.

[34] Contraries are treated by Aristotle in the *Categories*, chs. 10–11.

c. *Our account and modern science*

Those of us who are accustomed to the terminology of modern science with its atoms, energies, and other such realities and those of us who even find it hard to think of science in our earlier and ideal sense may be quite unsettled at this point. What is the relation between primary matter and two contraries on the one hand and, on the other hand, the entities studied by atomic physics? Is primary matter a thing like neutrons or protons or some other fundamental particle, and are the contraries the number of fundamental particles as they vary from one kind of atom to another? Such questions are raised here only to remark that they are premature. *For we are dealing with material reality at a level much too general and too vague to employ the very particular and very distinct concepts so useful in modern physics.* We are dealing with mobile being as we can know it at the beginning of our science, whereas the atomic theory, together with its refinements, can only be introduced after our general science of nature is behind us. Experiment and measurement, as providing us with refined and specialized dialectical inductions[35] that there are atoms and parts of atoms, can at most fill out the details concerning the first contraries and their subject which are known to us prior to deliberate experimentation and measurement. The knowledge that there are substantial changes takes place at a much more general and hence more certain level of our science than any evidence tending to deny substantial change, and hence no arguments from modern scientific theory can deny the reality of substantial change. In its general notions of nature the mind, as we have seen, is most trustworthy and certain; any contrary evidence is relatively uncertain and relatively obscure.

VIII. DIALECTIC THROUGH LANGUAGE AND ART

a. *Testimony from language*

Opinion received from successful students of the physical world is at least one way of raising the dialectical questions which lead, at last, to the inductive knowledge that nature has three first principles: primary matter and two first contraries. The analysis of language and of art, the two other dialectical devices already mentioned, likewise prepares the way for the same inductive conclusion and does so in an

[35] A dialectical induction is one in which the dialectic cannot be discarded. Such inductions remain colored by the theory, e.g., the atomic theory, in the light of which they were made.

even more positive fashion[36] than the opinions of other thinkers. If first principles can be found in material things, a science of nature becomes possible.

Following Aristotle's own example,[37] let us analyze the various grammatical forms of describing the process of learning music. It is possible to characterize a person's learning of music in at least three ways: "The man becomes musical"; "The non-musical becomes musical"; and "The non-musical man becomes a musical man."

The third manner of speaking is more complete, and it will be instructive to see how this third statement reveals the principles of coming-to-be.

In spelling out that "The non-musical man becomes a musical man," a speaker tells us that there is a man, that he was non-musical at the beginning of the process, and that he is musical at the end. Our dialectical conclusion based on this use of language invites the mind to induce the following propositions about mobile being: there is always a subject to which motion is attributed, e.g., man; there is something new which exists in the subject as the result of the motion, e.g., the quality of being musical; and this new item could be brought into existence through motion only if it did not exist beforehand within the subject undergoing motion, e.g., only if the subject were previously non-musical.

As shown by our induction, change involves something complex at both its beginning and its end. At the beginning, there is the composite of non-musical and man; and at the finish, there is a composite of musical and man. To say that "The non-musical man becomes a musical man" is a more complete and hence more perfect way of describing the process of learning music than either of the other two propositions we have cited above; what is described by these two other propositions would, upon analysis, be found to be more fully expressed by our third proposition. When we say that change in general involves the complex, we are actually using a different line of approach to establish the same conclusion which we reached in the previous analysis: in any change, there is a subject, e.g., man, and two contraries, e.g., non-musical and musical. When the change involved is substantial, the complex term at the beginning of the process consists of the first principles, primary matter and privation, while at the end of the process there are the first principles, primary matter and a possession.

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[36] *Commentary on the Physics,* Bk. I, les. 12, n. 98.

[37] *Ibid.,* les. 12, n. 101 ff.

Such are the dialectical conclusions based on our language. An inductive test will make them certain.

b. Examples from art

Our dialectical search can also take a cue from the world of art. *In the making of a statue, for instance, bronze that lacked a definite figure at the beginning of the sculpturing possesses that figure at the end.* Here again there is a subject (bronze), a privation (the lack of the figure), and possession (the having of the figure).[38] In an awkward but succinct way of describing the process of sculpturing, unfigured bronze becomes figured bronze. Once more each end or term of the change is complex. In the building of a house, matter which is deprived of certain shape at the beginning possesses it at the end.

A similar fourfold structure can be found in every type of coming-to-be: (1) a subject which (2) did not have a certain character is now, because of change, (3) the subject (4) having the character in question. The subject is the same at the beginning and at the end of the process. It is the same man who is first non-musical and later musical, the same bronze that lacks a figure and then possesses it, the same material that formerly was not in the shape of a house and later had such a shape. It can be argued, then, that there are three principles of motion, a subject and two contraries; it can be further argued that there are three first principles of substantial change, primary matter (the subject that undergoes substantial changes) and the two first contraries which such change embodies (possession and privation).[39] In every process of becoming, there is (1) that which terminates the change and (2) that to which the change is attributed. And the latter is twofold, namely the subject and the contrary of that which terminates the process. Hence it is evident that in any process of becoming three principles are involved: the subject, the terminus of the process, and its contrary. For example, when a non-musical man becomes a musical man, the contrary is the non-musical, the subject is the man, and the terminus is the musical.

IX. NOMINAL DEFINITIONS

a. Three requirements for motion

In the reddening of an apple, an apple that was not red becomes red; in the growth of a dog, what was not large becomes large. From not being on the ground, a falling snowflake becomes present on the

[38] *Ibid.,* les. 12, nn. 106–109. [39] *Ibid.,* les. 13, n. 118.

ground. Even in changes of substance, as in the burning of paper, the rusting of iron, and the assimilation of food by living things, there must be a subject which remains constant throughout the process and, by the end of the process, acquires a character that it could not claim before. Substantial change, as illustrated by the examples just given, is a change of a whole mobile being rather than an accidental or superficial modification; and here too *there is a subject which has at the end of the change something it lacked at the beginning.*

Accidental change requires a subject plus two contraries, and substantial change requires a primary subject with two first contraries. Primary matter and its two first contraries are the first principles of nature.[40]

b. Subject, form, and privation

By way of establishing now some nominal definitions, there is something in any change, whether accidental or substantial, that remains throughout that change. This stable something that persists through change is the subject that we call matter.[41] In the case of substantial change, this subject is primary matter; and by contrast the subject in accidental change, the substance that receives new accidents, may be called secondary matter.

In addition to the subject which persists throughout the change, there is a new modification which the change brings about. The subject acquires a new attribute. This new modification or attribute is called form, accidental form in the case of accidental changes and substantial form in the case of substantial changes.[42]

As we know from freshman Latin, *matter* (*materia*) once had the meaning of forest, and since wood is a common subject for man's making of things, it is easy to see how the term *matter* could be used (by extension from the familiar world) to mean any subject of change.[43] Form obviously originally had a geometrical meaning. Shape is the form that we know most exactly; but since shape is a terminus or boundary, the term *form* could be imposed to mean the terminus or end of any change.

A warning is in order here lest matter in the sense in which we

[40] *Ibid.*, les. 11, n. 85.

[41] *Commentary on the Physics*, Bk. IV, les. 6, n. 464.

[42] *Principles of Nature*, ch. 6.

[43] The Greek for matter is *hyle* and has the same primitive meaning as the Latin term. The relevance of this terminology is implicitly acknowledged in the cosmology of G. Gamow who speaks of the original stuff of the universe as "ylem" in *The Creation of the Universe* (New York, 1952), p. 55 ff. However, "ylem" seems to be a thing (*principium quod*), not a principle (*principium quo*).

are using the term be confused with matter in its ordinary meaning of that which has weight and occupies space, and there is an even stronger temptation to think of form as meaning only shape or figure. Substantial change, as we have seen, is a change of a whole mobile being, yet there is some perduring subject (primary matter) which remains throughout the change. Hence it is obvious that, when we speak of primary matter, we have in mind something much more fundamental than the derived characteristics of material reality, such as having weight and occupying space. Matter, in our nominal definition of the term, means the subject of change; primary matter is the subject of substantial change, and secondary matter or substance is the subject of accidental change. Form means no more (and in fact no less) than the modification or termination of matter;[44] it is substantial form that terminates primary matter and accidental form that terminates secondary matter or substance.

Primary matter and substantial form provide us with two of our first principles for change. But, as we have already seen, every change requires a subject and two contraries. *Matter is the enduring subject of change; form is the contrary, modifying matter at the end of the process of change; and privation is the other contrary motion involves.* As such it is our third principle for change. Privation is a principle in both substantial and accidental change. Accidental change requires the previous privation of the form that is to result from the motion; and substantial change requires the antecedent lack or privation of that substantial form which is to be present at the end of the process. The terms matter and form as used in this book may seem strange; but we are merely attaching names to realities whose existence we have established and we have justified these names by going back to the context within which they were first used.

c. Some concluding observations

Matter, primary or secondary, is always the potential. It is capacity. The dog, as subject for growth, is the capacity for such growth. *Form, substantial or accidental, is the actualization or act of the matter.* The new size of the dog is the act of the capacity in the dog for such a size.

But the puppy, though potential to the new size, is something actual in itself. It is actually a dog in substance, actually is of a definite color,

[44] Form, in a wider meaning than figure, is illustrated in L. Whyte, *Accent on Form* (New York, 1954), p. 28. But form here has the meaning of structural pattern. Our meaning of form is as the source or principle of this pattern.

size, etc. *Primary matter, on the other hand, has no actuality of its own; substantial form is the first act it possesses.* If it had any act of its own, then the union of primary matter and substantial form would always be accidental and extrinsic;[45] an extreme example of such extrinsic unity is that of the links in a chain which are merely attached and which do not compenetrate each other. But substances, from dogs to trees to inorganic things like paper or iron, have an intrinsic unity. Each substance is one thing. It is because of this intrinsic unity in a material substance that we are forced to the conclusion that primary matter is purely potential or the indeterminate. Werner Heisenberg, one of the greatest of twentieth-century scientists, claims that recent physics has reasserted, at a level far more specialized than the general science of nature, the reality of primary matter.[46] But, whether Heisenberg is right or wrong, primary matter should not be conceived as a stuff or a complete substance. If this were so we would have to analyze it into a subject, form, and privation. And so *ad infinitum.* As an ultimate matrix, it is a unique principle. We cannot conceive *what* it is. We can only show *that* it is.

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[45] *Commentary on On Generation;* Bk. I, les. 10; *Summa Theologiae,* I, q. 7, a. 2, reply 3; I, q. 66, a. 1; I, q. 115, a. 1, reply 2; *Summa contra Gentiles,* Bk. 2, ch. 43; *On the Power of God,* q. 4, a. 1; *On Spiritual Creatures,* ch. 8.

[46] *Physics and Philosophy* (New York, 1958), p. 160 and *passim.* But this is not a physical proof for primary matter. For how it relates to such a proof, see my *Science and Philosophy, op. cit.,* ch. VII, esp. p. 241 ff.

CHAPTER III

THE SUBJECT OF STRICTLY NATURAL SCIENCE

I. PROBLEMS PRELIMINARY TO OUR SCIENCE

a. Problems so far discussed

In the previous chapter we have seen that the coming-to-be and passing away of mobile being depends ultimately on three principles: the first subject or primary matter, the substantial form determining that matter, and the previous privation of that form. These are truly necessary and universal principles of nature known through motion at that general level of knowledge where the mind is most at home. And since they exist in the natural or physical world, *it is possible to construct a certain knowledge of nature in terms of its natural causes and principles.*

b. Two new problems

Our next task is to determine more precisely what the subject of our science is and what are the middle terms by which demonstrations are made concerning the subject.[1] Every science has a distinctive subject; every science, by the use of middle terms that represent causes, demonstrates the properties of its subject. What is our science of nature about and through what kinds of causes are demonstrations made regarding our subject? These are the two questions that Aristotle asks and claims to answer in Book II of his *Physics* after establishing, in Book I, that there are first principles in our mobile world. The problem of the subject of our science and its middle terms of demonstration occupy this and the following chapter of this book.

Like the material considered so far, even the two questions raised in Book II of the *Physics* do not push us past the threshold of a truly

[1] *Commentary on the Physics,* Bk. II, les. 1, n. 141.

scientific knowledge of nature. No demonstrations have yet been made in this science; and until we know precisely what the subject of our science is and what are the middle terms by which we can demonstrate the properties of this subject, no demonstrations in natural science are possible.

II. EXAMPLES OF NATURE AND ART

a. Two lists of examples

Natural things, that is, those things whose principle is nature, constitute the subject of natural science.[2] But what is nature? In order to define nature and defend our definition, it will be best to use division, the way to definition; *in other words, an understanding of nature will here be approached by contrasting nature with its opposite. One opposite is art.*

Some things come to be by nature and some by art. If we can establish the difference between these two kinds of becoming, we will be on the road to an understanding of what nature is, and when we understand this, we will know better what our subject is, i.e., the things that come to be or are by nature.

Let us first of all list several things that come to be by nature and several that come to be by art:

Nature: (1) trees naturally grow; (2) iron rusts by nature; (3) silver tends to fall of its very nature; (4) sheep naturally grow wool; (5) by nature, wood burns.

Art: (1) a house is a work of art; (2) a sentence is the product of the art of grammar; (3) Michelangelo's statue of "Moses" is an artifact; (4) human art makes woolen clothes; (5) card-playing is an art.

b. Etymology of "nature"

In the etymological meaning of the term, "nature" is derived from the same Latin root as our English word "nativity."[3] *In the first imposition of the term, nature has to do with the process of being born.* Our English word "physical" comes from the Greek word meaning birth,[4] so that natural and physical are taken in this book as synonymous terms. Another term for natural is mobile, and since everything material is mobile,[5] the word mobile can be added to our list of synonyms.

[2] *Commentary on the Physics*, Bk. I, les. 1, n. 3.

[3] *Commentary on the Metaphysics*, Bk. V. les. 5, nn. 808–820.

[4] *Metaphysics*, Bk. V, les. 4 (*passim*); A. Taylor, *Aristotle* (New York, 1955), p. 63.

[5] *Commentary on the Physics*, Bk. I, les. 1, n. 3; *Principles of Nature*, ch. 5.

What is born comes to be from within a parent. A parent has within itself an intrinsic principle for producing its like. By an extension of the term, nature came to designate an intrinsic principle for originating motion, whether in the living or the lifeless world.[6]

c. Meaning of nature

If we inspect the two lists of examples given before, we will see that all things in our first list (those whose origin is nature) have a very striking resemblance, and in this respect they differ from all works of art. *What comes to be by nature has within itself a principle of motion and of rest*; what comes to be by art does not have an intrinsic principle of this kind; its reality as a work of art is imposed upon it from the outside, namely, by the human mind.[7]

This difference can be seen very strikingly by considering the growth of a tree. A living tree has within itself a principle of motion, such as a power to grow, to repair itself when damaged, and to produce seeds. It is not simply the algebraic sum of forces acting upon it from the outside. Even though such outside forces are necessary if the tree is to grow or reproduce itself, the tree has something from within. When this intrinsic principle is gone, as in a dead tree, all of the outside forces like the sun, water, and carbon dioxide, which previously had fostered the growth and other activities of the tree, are now powerless to make it behave as a tree. An acorn planted in the proper soil will naturally tend to grow into a giant oak tree; but if the acorn is dead to begin with, i.e., if it does not have within itself a principle of life, the best soil in the world will not make it grow a fraction of an inch.

d. Nature contrasted with art

Although an acorn will tend to grow into an oak tree, the wood in the tree will not naturally tend to form a house. To make a house, man must operate on the wood from the outside. To make a house, man must cut the wood, smooth it, place the boards in proper relationship to each other, and fasten them together. *Thus in art, the prin-*

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[6] Great philosophers on nature in modern times have, like Aristotle, used a biological model for understanding matter. Thus, Whitehead has a philosophy of organism, *Process and Reality* (New York, 1957), pp. 63, 75; Teilhard de Chardin speaks of the "psychic" and the "within," *The Phenomenon of Man* (New York, 1959), ch. 2; Bergson's language was that of a "vital impetus (*élan vital*)," *Creative Evolution*, transl. A. Mitchell (New York, 1911), p. 87 ff.

[7] *Physics*, Bk. II, ch. 1, 192b, 12–23; *Commentary on the Physics*, Bk. II, les. 1, n. 142.

ciple of motion is not within things; the principle of making in the case of a work of art lies in human reason.[8]

By its own nature, iron rusts in the weather; rusting is not a work of art. But a sentence is clearly a work of art, for never by their nature would sounds take the arrangement, make the pauses, and form the inflections which the human art of grammar gives to them. With all of the sounds it makes, no animal ever comes close to forming a sentence.

Silver dropped from a height above the ground will, by its very nature, tend to fall toward the ground;[9] but Michelangelo's "Moses" had to be made or moved by something outside nature, namely, human reason. In a similar way, the growth of wool results from a principle within the sheep; but a woolen suit or dress is a product of human reason.[10]

III. SOME OBJECTIONS TO OUR CONTRAST

a. The difficulties stated

En route to our definition of nature, it has been instructive to divide nature from art and to make the induction that what comes to be by nature has its principle of motion within itself, whereas a product of art has its principle in human reason. However, there are several difficulties which indicate that our induction may not be a good one.

In the first place, there are surely instances where art and nature cannot be distinguished. If you found three pebbles arranged in the form of a right triangle on a college campus, it would certainly be possible to attribute their positions to natural circumstances. But they could also have been arranged by an eager student interested in the Pythagorean theorem. In cases of this sort, art and nature appear indistinguishable, and it would look as though our distinction between them is not supported by experience.

As a second objection, by attributing to nature an intrinsic principle of motion, it would appear as though we are attributing too much to spontaneity; *it might seem as though we are allowing nature to do things without the need of an external cause.* Surely the iron would not rust except under the action of the rain and the atmosphere, and the sheep would not grow its wool without such extrinsic causes as the grass it eats, the air it inhales, and the energy of the sun which

[8] *Commentary on the Metaphysics,* Bk. XII, les. 3, n. 244.
[9] *On Truth,* q. 23, a. 3; q. 24, a. 1.
[10] *Physics,* Bk II, ch. 1, 192b, 33 ff; *Commentary on the Physics,* Bk. II, les. 1, n. 142.

provides a proper temperature. To view natural things as invested with an internal principle of motion would almost appear to be claiming that what is natural is self-moved or self-caused.

As a final difficulty, art also would appear to have a principle of motion within itself. A woolen garment will become worn and tattered from use. A house, over the years, will tend to become run-down. In the course of time, many great works of art have deteriorated and required periodic restoration. Did not "Venus de Milo" lose her arms? Hence it might seem that art, as well as nature, has a principle of change within itself.

These objections must be successfully met if our division of nature and art is a good one and if our division can lead to the inductive knowledge that nature has within itself a principle of motion while art does not. Such inductive knowledge, if true, will be included in our final definition of nature, but it cannot be true if our objections hold.

b. The difficulties answered

The first objection actually calls attention to a so-called borderline case. *Admittedly there are many cases when it is humanly impossible to decide whether a given effect is the product of nature or of art; nonetheless, such a practical difficulty in human knowledge does not abolish the distinction in reality between the natural and the artificial.* It means only that we do not have enough information to determine whether the object under investigation is one of nature or of art. There are many such borderline cases in various fields of inquiry. Thus biologists at times have been unable to decide whether some objects of their inquiry are living or lifeless substances. But this does not mean that there is no distinction between life and non-life. It means only that we are unable to muster enough information to discover how our distinction applies. A similar problem is met in classifying organisms intermediate between the plant and animal kingdoms. They must belong to one or the other, but facts are wanting to decide the issue. Finally, and this brings us to our present problem, it may be difficult and even impossible to decide in certain cases whether a given work is one of art or of nature. It would certainly be admitted by everybody that the Empire State Building is a work of art and the growth of sheep's wool a product of nature, so that between art and nature there is a clear and certain distinction in principle. But how this distinction applies in each particular case is another question. Our failure to apply this distinction in particular cases in no way denies that there *is* a distinction and that, did we only know enough, we could find it.

In meeting the second difficulty, it can be countered that our notion of nature does not abolish the need for external causes — like grass and air in the case of sheep and the weather in the case of the rusting iron. Such causes, however, do not enjoy an absolutely free play over their effect; the effect is not at the complete mercy of external causes producing it. *The materials on which such causes operate will contribute from their own nature to what the final effects will be.*[11] Thus, the same weather that will cause iron to rust will cause the acorn to grow. Why? Not because of the extrinsic causes — for they are the same, i.e., the same weather, in each case — but because of the material on which they act, the seedling in one case and the iron in the other. Each of these materials responds to the weather on its own terms and by its own nature. Each has a character within itself that, even when extrinsic causes are alike, makes the final effect to be different and distinctive.[12] Hot weather that will melt the snow may kill the grass underneath. This is not because of the differences among external causes — there is the same hot weather in both cases — but because the snow and the grass have an original character of their own and from within themselves. This inner principle is the nature of each. To sum up, then, our answer to the second objection, motion will always require an extrinsic cause of some sort.[13] But the material on which the cause works reacts to that cause according to its own inner principle of motion, i.e., according to its own nature. To speak of nature is to speak of the original, intrinsic character possessed by each kind of mobile being.

Lastly and by way of approach to our third problem, it should be pointed out that a work of art is never pure art. There is always some natural component in the work: there is the lumber in the house, the wool in the garment, the marble in the statue. The artist in our usual meaning of the term art invests this natural component with a pattern or character that it would not assume when left to the forces of nature alone.[14] It is this natural component which contains within itself a principle of motion or change.[15] *Thus, a work of art undergoes change not because it is a work of art but rather because of the natural component on which the artist has worked.* Garments tear not because they are garments but because they are woolen; given the

[11] *Summa contra Gentiles,* Bk. II, ch. 22.

[12] J. Weisheipl, "The Concept of Nature," *The New Scholasticism,* XXVIII (1954), 379–408.

[13] Cf. *infra,* ch. VIII.

[14] *On Truth,* q. 2, a. 5; *On the Power of God,* q. 6, a. 3.

[15] *Summa contra Gentiles,* Bk. III, ch. 65.

same causes, each garment tears in different ways depending on the material of which it is made. Houses are attacked by termites not because they are houses but because they are made of lumber. In the case of a statue, "Venus de Milo" lost its arms not because it was a statue but because it was made of marble.[16]

c. *Further difficulties*

Further objections might be alleged against our division of nature from art on the basis of modern physics with its making of new kinds of atoms and on the basis of modern genetics with its making of new strains of living things. Is plutonium or a laboratory-induced mutation a work of art or nature?

Indeed, by virtue of his refined knowledge of both the lifeless and the living worlds, *twentieth-century man has been able to make new kinds of things that do not naturally occur and yet, when made, seem as natural as many other things of experience or experiment.* A number of elements that, as far as we know, do not occur in nature, have been synthesized by contemporary physics; and geneticists, by the use of X-rays, have produced mutants in living things, for example, fruit flies, which do not naturally occur. Both the new elements and the new fruit flies seem to be natural things. They have within themselves principles of motion and apparently fulfill the meaning of nature previously defined and defended. But they are produced by man. Are they nature or art? Can man by his art make things that have, not from him but from within themselves, that principle of motion we term nature?

d. *The modern scientist as an artist*

In order to approach this problem, let us emphasize two important points. *First, nature has been characterized as an intrinsic principle of motion. Second, there is no such reality as pure art;* and, when the artist merely assists nature toward an effect which natural causality could also produce, e.g., health, he can be called in a special way a cooperator with nature. Such an artist arranges nature so that the effects he wants will come forth from within nature.

No matter how a thing comes to be, it can be said to be by nature as long as it has within itself a principle of change. To take an example of medicine, it can be observed that what a living thing tends to do under the influence of a doctor's art it also tends to do on its own; and it can likewise be seen that a doctor studies how living things

[16] *Physics,* Bk. II, ch. 1, 192b, 19–21.

tend by nature to cure diseases in order to assist and strengthen these natural curative tendencies. Let us take a living thing, even a man, restored to health by an antibiotic after an infection; at least by the time the cure is effected, the person can be said to have health by nature. For nature was the principal cause of the healing; the doctor was only a cooperator. Let us assume that the person had such a type of disease that he would have recovered health without the doctor's aid, but only after a longer time and after suffering more inconvenience. The doctor was an instrument, a cooperator, serving another and more important cause, namely the living thing, and the living thing itself, at least after recovery, is said to be healthy now by nature and through its own power. Nature is always the principal cause of health; health comes from within the organism, as from an intrinsic principle; the doctor can never be anything more than an aid to whatever life is still present in a sick person.

Now something similar may be alleged to take place in atom-building. The physicist finds out how nature operates in combining various subatomic particles to yield the elements we now know, and since every artist imitates nature more or less, the atom-building physicist takes advantage of nature's own tendencies by bringing particles into such positions that natural forces will take over to produce new elements. Like a doctor disposing a sick patient in such a manner that the natural therapeutic tendencies of the living thing can the better restore health, the physicist arranges nature in such a fashion that its natural tendencies will operate to produce new elements; moreover, like the recovered patient, a new element will have an intrinsic principle of motion even though it came about by art. Whatever has an intrinsic principle of motion has a nature.

In this respect, the physicist resembles artists who cooperate with nature, and in this respect too, the atom-builder conforms to the general requirement of all art that it study nature's laws so that, by obeying them, matter can be better exploited and made an ever more obedient servant of human purpose.

Our two principles used to show how atom-building, as an art, can bring about new things that can be said to be by nature, e.g., plutonium and neptunium, can also be applied to solve the problem raised by genetics. Such principles have application even to the new space satellites where man again, having found out how nature does things, becomes a cooperator with natural tendencies and forces that he must obey in order to command.

Nikita Khrushchev's proud boast that the man-made Russian satellites have shown that there was no need for a God to make the heavenly bodies reflected, for one thing, a common failure to see art as the ability to use law-abiding powers and tendencies already existing in nature itself. If there were no natures, moved as we shall see by a First Mover, there could be no art. For art, whether in the making of a grass hut or in the spectacular production of an orbiting space satellite, is always a derivative and secondary phenomenon.

IV. THE DEFINITION OF NATURE

a. The explanation of the definition

"Nature," according to Aristotle who made the first elaborate analysis of what it means, *"is the principle of motion and of rest in that to which it belongs essentially and primarily and not accidentally."*[17] This definition is an expanded version of the previous insight into nature as an intrinsic principle. Because nature does not belong to any single one of the categories, and because real definitions can be given only for things falling into one of the ten categories, the foregoing formulation is only a nominal rather than a real definition. Each part of it must now be explained.

Nature is a *principle.* This means that nature is a source of something. It is related to motions which flow from it as cause is related to effects.

It is a source or principle of *motion* — of the rusting of iron or the growth of a tree or the production of wool by sheep.

It is also a principle of *rest.*[18] A stone, dislodged from a mountainside, falls by nature and, when it reaches the valley, is at rest by nature. In the latter case, to be at rest is the way in which its nature reacts to external circumstance. Iron, lying on the surface of the earth, is at rest there by nature; a dog or a cat when asleep is also naturally at rest.

Nature is *in* the thing to which it belongs, and in this way nature differs from art. In the light of the example in the previous paragraph, the principle of the stone's motion and of its rest is in the stone itself; under the same circumstances which bring about the motion of the stone, a twig might remain immobile. In kindred fashion, causes which produce a violent agitation of the air might leave a stone completely at rest. In each case, where extrinsic causes are alike, the difference in motions or between being moved and being at rest depends on the

[17] *Commentary on the Physics,* Bk. II, les. 1, n. 145; *Physics,* Bk. II, ch. 1, 192b, 21–23.

[18] *On the Power of God,* q. 6, a. 5, reply 5; *On Truth,* q. 22, a. 1, reply 11.

inner character, the intrinsic principle, the very nature of the stone, the twig, and the air.[19] Art, on the other hand, has its principle from outside the thing made or done.

Nature is in a thing *essentially*. It is part of the very constitution of the thing in question. There are men who are five feet and men who are six feet tall. Such a difference is accidental to their nature. This nature is essentially to be a rational animal. For copper to be shaped into a roof or a water-pipe is accidental to copper; what is essential to it are the principles of those properties studied by chemistry and physics, the charge on the copper, its valence, specific gravity, etc.

Nature is a thing *primarily* or properly.[20] To be in a thing primarily is to be there by reason of the whole of that thing and not by reason of its parts. Thus, man has reason primarily and taking his nature as a whole; he has fingers by reason of his parts. Man has weight not because he is rational but because he is mineral, having a physico-chemical constitution. Weight is essential to man; so indeed are fingers. Neither of these is accidental to man, but neither of these belongs to man primarily or properly. A primary characteristic is peculiar to the particular species to which a thing belongs, like reason in the case of man. We do not know the natures of things in a differential way until we have attained to their primary or proper characters. Just as reason is primary in the case of man, so for example is the specific bark of a dog or rather the principle of which barking is a sign; othe characteristics that are signs of primary principles include the peculiai atomic structure of each kind of element, specific gravities, boiling points, etc. Because of the difficulty in knowing what is primary or proper in things, we often use the terms nature and natural for any essential intrinsic characteristic even though that characteristic is not primary. Thus we say that man walks by nature or naturally even though he does so because of the genus to which he belongs and not because of what he has primarily. To know what is essential to a thing but not proper to it is to know its nature in only an imperfect way.

Nature is *not in a thing accidentally*, and in this respect what is by nature is contrasted with what is by chance. Freaks in the material world like tidal waves, or monstrosities like blind cows or crippled dogs are chance events. They are disorders. They are accidents of nature but not nature in the strictest sense of the term.

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[19] *Summa contra Gentiles*, Bk. II, ch. 22.

[20] The explanation of John of St. Thomas, *Curs. Phil., Phil. Nat.*, P. I, Q. IX, a. 1, ed. B. Reiser (Turin, 1930), II, 170 ff. esp. 173.

b. *Is natural motion relative?*

The accidental or incidental occurrences in the physical world will be the subject of discussion later on.[21] But one kind of incidental relationship, if mentioned here, may considerably help to clarify our definition of nature itself. In order to illustrate the point at issue, let us imagine a man walking backward at four knots on a ship that is moving forward at four knots. With respect to the ship, the man is moving; but with respect to the harbor he has just left behind, he may be said to be immobile. It would look as though our definition of nature is relative, in the sense that motion depends upon our point of view. From the ship, one report of the man's motion will be given, and he will be said to be in motion, while from land he will be said to be at rest. If motion is relative in the sense of being dependent on our viewpoint, so is the principle from which the motion comes, and our definition of nature will thus turn out to be almost useless in the study of the physical world.

A mathematical approach to the physical world, with its interest in measure and number, may well be unable to determine whether the man on our ship is moving or not; it may well be inadequate for the task of determining whether there is any fixed principle intrinsic to things. An approach of this kind may prevent us from deciding what is intrinsic and what is extrinsic. A strictly physical or natural approach to our universe, however, can rescue us from the relativity implicit in the mathematical approach. Such an approach is based on motion, not on quantity. *It can truly be argued that the man is performing a motion natural to him, namely that of walking. This is something absolute.* It is accidental that he is walking on a ship, and it is also incidental that he should be walking on something immobile, if there really is such a thing. Much the same problem would be met if we imagine a fish swimming in a direction opposite to the spinning motion of the earth at the same speed as the spin itself, and under such conditions that the fish, with respect to the earth, appears motionless. Once more a purely metrical approach to nature cannot determine whether there is any absolute motion going on and hence what principles of motion, if any at all, are in play. But the physical or natural study of nature can maintain that, no matter what relative velocities may be involved, the fish is engaged in its natural motion of swimming. This is something pertaining to the nature of fish. That the body of water in which the swimming goes on is itself in motion is accidental to the natural motion of the fish.

[21] Ch. IV.

V. ART AS AN OPPOSITE TO NATURE

a. Art as a Product of Reason

In contrast to what comes to be by nature, a work of art is always a product of human reason. There are several kinds of work which reason produces, and it would be valuable in another context to explore all of these kinds of art with the numerous divisions and subdivisions that such a study would entail. However, art can be discussed here only insofar as it gives us greater insight into nature as we have just defined it.

Grammatical sentences are not found in nature. They are made by man; they are products of art. So too are logical definitions, logical propositions, and arguments; all such entities are made by human reason and can therefore claim to be works of art. A very common form of art is in the realm of mechanical tools — forks, hammers, automobiles, golf clubs, airplanes, television sets, and pressure cookers; the works of mechanical art, though produced by the mind, exist in the external world. Perhaps the most common meaning attached to the term art in contemporary English is that of the fine arts — painting, sculpture, mosaic work, wood carving, etc.[22] We take art in the traditional sense of any product made under the direction of human reason.

b. Art as an imitation of nature

In a technological age like ours, it is important to reexamine the proposition that art is an imitation of nature.[23] Such an expression can easily lead to misunderstanding and must be carefully explained. To conclude that art is an imitation of nature does not mean that the artist copies or mimics nature like a mechanical camera. It does not bind the artist to report on nature with the algebraic detail of a mathematical physicist. *As an imitation of nature, art cooperates with nature and completes it.*[24] *To view art as an imitation of nature is to find it as an extension and perfection of nature.* This can be seen from several examples.

Art extends and perfects nature. A hammer is an extension or imitation of the human hand; without it, man would have to pound

[22] For an excellent discussion of the division of the arts and of their interrelations, cf. B. Mullahy's "The Nature of the Liberal Arts," *The New Scholasticism*, XXIII (1949), 361–386.

[23] *Exposition of the Posterior Analytics*, prologue.

[24] *On Truth*, q. 11, a. 1; *Summa Theologiae*, I, q. 117, a. 1; *Commentary on the Physics*, Bk. II, les. 13, n. 258.

things together with his fists or use some other way of fastening what he now does by driving nails. An automobile is a development of man's natural power of locomotion; without it and without other means of transportation that would be equally a development of our natural locomotion, man would have to go about entirely on foot. Speech is natural to man, the rational creature, just as locomotion is natural to him as an animal; the languages he invents build upon that natural power of articulate expression; they enable that power to extend and perfect itself. As grammar is to speech, so logic is to reason. Logic perfects the rational power of man.

If, therefore, art is an imitation of nature, such a view by no means condemns the artist merely to make carbon copies of experience. The artist develops and refines what nature provides in less perfect form. Even in the case of painting and sculpture, for example, the artist, by selection and emphasis, distills out meanings and values that are in nature, bringing into greater clarity and order the natural potencies that things have for being appreciated by us. Art imitates nature even in the fine arts by extending and refining what nature presents in grosser form.

c. *Arts cooperating with nature*

From what has just been said, there are grounds for concluding that every artist cooperates with nature, because he develops nature and perfects what nature incipiently provides. *Yet there are certain arts that work with nature's tendencies in so intimate a fashion that we reserve for them in a special way the name of "arts cooperating with nature."*[25] As usual, the difference between arts cooperating with nature and other kinds of art can best be seen by employing examples.

A rather obvious kind of an art cooperating with nature's tendencies is the art of medicine. Many sick people, even though they call in a doctor, would be cured by the natural therapeutic tendencies in all living things without professional assistance. In such cases, the doctor does no more than speed up the process of recovery. Health may thus be restored in a great many cases either by nature's own causality or by the causality of the art of medicine, both of which cooperate to the same result. Another art of a sort similar to medicine is the art of teaching. There are many things which a learner can learn for himself, and in such cases the teacher once more only accelerates the process. Here, in a manner similar to our example taken from medicine, a result, called knowledge in a learner, can be

[25] *Physics*, Bk. II, ch. 1, 192b, 23–33.

produced either by the nature of the human reason operating on its own unaided natural level or by means of the art of teaching. The same effect can thus be produced by either chain of causality.[20]

d. Other arts

Unlike our examples in medicine and teaching, there are certain effects which nature could not produce. Our arts cooperating with nature show that the nature of a living thing can restore health by itself and that the nature of human reason can attain truth by itself. *But nature does not build ranch houses or airplanes; it does not print newspapers or install telephones.* Such products require human reason. They are always works of art. But they do not work with nature in so intimate a fashion that they can properly be called, like medicine, teaching, or agriculture, arts cooperating with nature. These kinds of art using nature to produce something that nature would not produce alone are more properly art than an art cooperating with nature. The reason why these are more properly arts is this: they are always a work of reason and never the product of principles intrinsic to our natural world. It should be carefully noted, however, that arts using nature or "additive arts," if we wish to use this term, are alleged to be purer forms of art but not necessarily to produce a better product than that produced by arts cooperating with nature, such as medicine or agriculture. We should likewise note that there are borderline cases where it is practically impossible to determine whether an art is one which cooperates with nature or one which merely uses nature.

But whether cooperating with a nature which already has an intrinsic tendency to the same end as the art itself or whether engaged in some other kind of work, every artist is required to study nature in order to be a successful artist. The doctor first tries to find out how nature tends to promote healing and then helps nature to reach its end. He finds, for example, that nature produces antibodies to destroy various germs; he then gives injections of these antibodies to strengthen and help nature. As an artist, the teacher tries to find out how the human intellect operates and then aids that intellect by cooperating with its natural tendencies. Even the maker of the first knife and fork was aware of the human hand in some crude manner in order to respect its natural tendencies.

From another angle and on the part of the matter employed, art would be impossible if there were no nature to imitate. The

[20] *On Truth,* q. 11, a. 1; *Summa contra Gentiles,* Bk. II, ch. 75.

builder of a bridge studies the laws of gravity, of stresses and strains, etc., and to the extent that he obeys — let us even say, in a wide sense cooperates with — these natural tendencies, he makes a successful product. The designer of an airplane is familiar with the laws of aerodynamics and, by obeying them, produces an airplane. Francis Bacon said that nature, to be commanded, must first be obeyed. By learning how nature can produce power and by respecting nature's tendencies, man has succeeded today as never before in harnessing matter to his own purposes.[27] All arts, cooperative and additive, thus imitate nature by perfecting and extending it and respecting and developing it. In this light, reference should be made to our previous discussion of artificially produced elements and mutations.

VI. MATTER AND FORM AS NATURE

a. Matter as nature

Under different aspects, both matter and form can be called nature.[28] In a special way the matter that we have called primary and the form that we have termed substantial can be called nature. *Primary matter can be called nature because primary matter is the basic source or matrix from which all physical things come to be.* Because primary matter is in things, it is an intrinsic principle. It belongs essentially to all the things of which it is a part.

In a genuine sense, nothing is a more basic source of motion than primary matter. Of its essence, it is nothing but a potency for form. Always deprived of all forms other than the one it bears, the primary matter in any material substance is ever restless and ready to surrender the form it owns in order to take on another. The whole history of our cosmos is the struggle of primary matter seeking to perfect itself. Primary matter is the intrinsic principle of change in all things.

b. Form as nature

From another angle, form can be called nature too,[29] for it is form which gives to matter a character or determination. *It invests matter with something original and specific, so that the various kinds of mobile beings differ among themselves principally because of their*

[27] Unrelated to first principles, modern science is but a preparation for such practical achievement. Cf. my *Philosophical Physics* (New York, 1950), ch. 5.

[28] *Physics*, Bk. II, ch. 1, 193a, 27–28; *Commentary on the Physics*, Bk. II, les. 2, nn. 149–150; *Commentary on the Metaphysics*, Bk. V, l. 5, n. 821.

[29] *Physics*, Bk. II, ch. 1, 193b, 7–12; *Commentary on the Physics*, Bk. II, les. 2, nn. 151–156; *Commentary on the Metaphysics*, Bk. V, l. 5, n. 821.

forms, which in each case give a different character to matter. Because it gives to matter a determination original and primary to the species, substantial form is more of a principle (a distinctive source for the activities proper to a given species of mobile being) than matter and, from this point of view, is more eminently nature than matter can be. Looking at our principles from the point of view of their coming into being, form is the terminus or end of matter and, as that which is principally intended by nature, is nature in a more profound way than matter.

Matter and form are both nature; and so our science of what exists by nature will be a science of things that are by matter and form. Natural mobile being in other words is really that which is constituted of matter and form. The composite of matter and form is not itself a "nature" but a thing that comes to be by nature.

c. Causes

The subject of natural science has now been identified. That subject is the things that are or come to be by nature.

But to have a science about that subject, according to the model of science in Chapter I, middle terms are required, and these, in the real world, are causes. Are there such causes in the natural world?

Matter, primary and secondary, and form, substantial and accidental, are two such causes.[30] Something results from them. If a cause is that on which something depends, matter and form may be called material and formal causes. They yield two types of middle terms by which a fully natural science makes demonstrations. *Another type of cause, yielding another type of middle term in natural science, is the agent, the producer, that which by its action brings about the union of matter and form.*[31] The agent is often called the efficient cause, but further consideration of it will be deferred until Chapter VIII, a context where the principle of efficient causality receives its most serious application. *A fourth type of cause, yielding a fourth kind of middle term, is the final cause, that for the sake of which natural motion occurs.*[32] Whether there are final causes in nature is our next question.

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[30] *Physics,* Bk. II, ch. 3, 194b, 24–29; *Commentary on the Physics,* Bk. II, les. 5, nn. 178–179.

[31] *Physics,* Bk. II, ch. 3, 194b, 29–31; *Commentary on the Physics,* Bk. II, les. 5, n. 180.

[32] *Physics,* Bk. II, ch. 3, 194b, 32–195b, 2; *Commentary on the Physics,* Bk. II, les. 5, n. 181.

CHAPTER IV

CHANCE AND FINALITY

I. SOME IMPORTANT DIVISIONS

One of the oldest questions in philosophy concerns the explanation of the order of our universe. Is it the result of chance or does it require us to recognize purpose in the cosmos? Though an old question, it is also a modern one.

a. Summary of extreme positions

Two extreme positions are determinism and indeterminism. The former, based in modern times upon the physics of Newton, holds to a rigidly mechanical order throughout the whole universe; chance is passed off as a mere matter of our not knowing how these rigid laws are operating in what we call "chance" events. Modern indeterminism, beginning with the biology of Darwin and supported by recent physical theory, finds chance to be a fundamental fact of nature. These two extreme views can bring the discussion of chance into focus.

b. Division among events involving nature

In evaluating both extreme positions concerning chance and in searching out the true solution to our problem, it will be valuable to make several divisions among the events in nature, beginning, as a general science must, with the more common and more vague notions that first impress our understanding and are incorporated into ordinary language. Through such a dialectic, a definition of chance can be established on inductive grounds.

1. Some events seem to happen in nature always, like the rising and setting of the sun and the regular motion of the great dipper around the pole star in the northern skies. To such motions, no

exceptions are observed, and such motions common "received opinion" never ascribes to chance. Other events happen for the most part: higher animals are born, for the most part, with normal eyes; it usually rains in April in northern United States. A third kind of event happens rarely and as an exception to other events of the same genus: thus, occasionally an animal, say a horse or a cow, is born blind; or there is an April drought. *It is in this third group of events, rare and exceptional with respect to other events of the same general type, that men find what they term fortune or chance.*[1]

2. *A second division of events contrasts things which happen for an end and things which do not.* Chance takes place only where things are working to a certain end or goal which philosophers call a final cause (from the Latin *finis* for "end"). We are expecting this aim or goal to be realized, and something unplanned occurs. Let us suppose a man digging in his garden comes upon an Indian arrowhead or even a tomahawk; he was intending one thing, the tilling of his soil, and something else, the unintended discovery of an Indian relic, came about. Such an unintended or unplanned event would be alleged as an effect or instance of chance or fortune in the common opinion of men.[2]

3. A third division, this time within those very events that happen for an end, contrasts things which occur through deliberation and things which occur naturally.[3] Building a house is an example of the first kind of event; the cycle of the seasons and the circulation of the blood are examples of the second type. *In both deliberate and natural kinds of events men commonly find chance.* Thus a builder could accidentally fall off a ladder, or circulation might become poor as a result of an accident. Both events would be ascribed to chance.

4. *A final division of events is that between those which are essential on the part of their cause and those which are accidental.*[4] There is an essential connection between being a man and having a sense of humor, but many other causal connections are accidental only, like being a man and being sunburned.

Such accidental connections, furthermore, may pertain either to a cause or to an effect.[5] (*a*) To attribute the building of a house to

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[1] *Physics*, Bk. II, ch. 5, 1966, 10 ff.; *Commentary on the Physics*, Bk. II, les. 8, nn. 208–210; cf. also G. Clark, "Chance and Monstrosity," *The New Scholasticism*, VIII (1934), 34–38, 45.

[2] *Ibid.*, n. 211. But what is unintended is not, by itself, necessarily by chance; cf. *Summa contra Gentiles*, Bk. II, ch. 6.

[3] *Commentary on the Physics*, Bk. II, les. 8, n. 213.

[4] *Ibid.*, n. 214; *Commentary on the Metaphysics*, Bk. VI, les. 2, n. 1186.

[5] *Commentary on the Physics*, Bk. II, les. 8, n. 214.

a musician is to name an accidental cause of the building; the house is built by a builder, the essential cause, and it merely happens that he is also a musician. There is an intrinsic and essential relation between the art of building and the house; between the house and the art of music, however, the connection is only extrinsic and accidental. This illustrates an accidental connection on the part of the cause. (*b*) Accidental connections may exist also on the part of the effect. That the house, as an effect of building, have a roof is essential to it; that it possess weak rafters or a faulty chimney is accidental, because such defects were not planned or intended by the builder who produced the house.

This fourth type of events we have been dividing and subdividing is most critical for identifying chance or fortune. Chance is not the essential but the accidental. Moreover, for a person to be tall or musical or bald-headed is to have certain accidental characteristics; but such accidental effects are not described as chance. Chance is said to be a cause. *When, among those things which happen for an end, and happen frequently, there is an accidental effect of rare frequency, we attribute the cause of such an event to chance; when such an event is in the order of strictly human affairs, we call it fortune or luck.*[6]

c. Conditions needed to identify chance

For an event to be attributed to chance or fortune, several things then are necessary:

1. There must be something accidental on the part of the effect, as in the finding of a tomahawk, or in the death of a cow through a lightning bolt. The causality of such an event we ascribe to chance.

2. The event must be relatively rare, i.e., an exception to the general pattern of events of a similar kind. When an event is frequent, its causes are not attributed to chance but are considered in some way to be ordered and essential.[7] An experimenter will usually repeat an experiment at least several times so that, by getting the same result each time, he shows that he has not chanced upon some freak or other but has penetrated into an essential order obtaining within nature. Frequency of occurrence is a common sign of order and of an essential connection among causes.

3. The effect must occur in the genus of events that happen for an end. Men do not commonly speak of chance unless they are ex-

[6] *Physics*, Bk. II, ch. 5, 197b, 5–7; *Commentary on the Physics*, Bk. II, les. 8, nn. 215–216.

[7] *On Truth*, q. 3. a. 1.

pecting some event to occur, whereas something else actually comes about.[8] There is, for example, no question of chance in the strictly mathematical order because mathematics has no interest in ends; connections like those in the tables of arithmetic or within the figures of geometry are always intrinsic and essential, part of the form. No one would say that by chance $1 + 1 = 2$ or that by chance the sum of the interior angles of a triangle is 180 degrees. Chance cannot affect these truths, as chance can affect a house, the gardener finding the tomahawk, etc. In other words, where there is no question of events happening for an end, there is no question of chance; and by the same token, where there is chance, there is always something that is acting for an end but becomes accidentally involved with something else acting for its own end.[9] The cause of this accidental connection is chance.

4. In the case of luck or fortune, the thing to which the accidental event happens must be a human being.[10] Chance among those events controlled by human will is called fortune. Good or bad luck, fortune or misfortune, are not ascribed to things not affecting man, except by some comparison or other with human affairs. It is possible to speak of a lucky horse that wins a race because winning a race is valuable not to a horse but to men; it is also possible to speak of an unfortunate animal that was killed by a car because such an accident would be considered a misfortune when happening to man. When a person thanks his lucky stars, it is he or she, rather than the stars, who is lucky. Hence, fortune is a kind of chance. *Chance is a cause of relatively rare and accidental deviations from the order, executed for the most part, between a thing and its end. Fortune or luck is chance as affecting the concerns of human will.*

II. CHANCE AND DETERMINISM

a. Chance is the result of ignorance

Further discussion of the nature and reality of chance can profitably take place by confronting the extremes of determinism and indeterminism to see whatever truth is contained in either of them.

Concerning the several aspects of determinism, it can first be

[8] For Henri Bergson, chance is always an order but a different order from the one we are expecting; cf. *Creative Evolution*, transl. A. Mitchell (New York, 1911), pp. 222, 232, 234, 274. For F. H. Bradley, chance is always relative to the given "system" we have in mind and, as in Bergson's argument, becomes only relative; cf. *Appearance and Reality* (London, 1897), p. 234.

[9] *Summa contra Gentiles*, Bk. II, ch. 75.

[10] *Physics*, Bk. II, ch. 6, 197b, 5 ff.; *Commentary on the Physics*, Bk. II, les. 10–11 (*passim*).

conceded that at least in one sense chance as such does not exist. It is always accidental, hence relative, and since the relative lacks some absolute or fundamental quality of existence, there is a certain sense in which chance, even more than other relative things, is deficient in regard to existence itself. It cannot be said to exist in an absolute sense.[11]

Moreover, chance is truly in some way a matter of human ignorance. *For one thing, failure to investigate all of the circumstances surrounding a given event may lead us to ascribe certain things to chance which are not really the work of chance at all but of hidden necessary causes; for another thing, even after a careful investigation of nature, human reason must always remain ignorant of all the connections, actual and possible, in our world of mobile beings.*[12]

In relating chance and human knowledge, or ignorance, it should be recalled that not everything accidental is chance. But chance is always among those things which are by accident; and wherever the accidental exists, there is a lack of determinism or order which restricts us to a defective understanding of the world. Now there is a necessary and determinate order between making a house and being a builder, but there is no such connection between making a house and being a musician, or being tall.[13] Consider the number of things that a builder can be besides being a builder; he can be tall or short, heavy or light, of this race or that, married or single, well dressed or shabby, belonging to this or that religion, hungry or full, and so on through an indefinitely large number of characteristics that might be added. All such characteristics are extrinsic to the art of building. They are accidental. The builder can have an indeterminate number of these characteristics besides his building art. Between being a builder and having these other qualities, there is no necessary, determinate, and intelligible connection; and since accidental connections do not follow any intelligible law, chance, as a form of the accidental, escapes our understanding and may truly be assigned to human ignorance.

b. Chance is not only human ignorance

Yet chance is not only human ignorance, as classical determinism would argue. Not all the connections in our world are necessary and

[11] *Commentary on the Metaphysics*, Bk. XI, les. 8, n. 2272; *Summa Theologiae*, II–II, q. 95, a. 5; cf. also J. McAllister, "Chance in Aristotle and Aquinas," *Philosophical Studies in Honor of the Very Reverend Ignatius Smith, O.P.*, ed. J. Ryan (Westminster, Md.), pp. 76–91.

[12] *Commentary on the Metaphysics*, Bk. XI, les. 8, n. 2286.

[13] *Commentary on the Physics*, Bk. II, les. 8, n. 214.

determinate, as our previous paragraph pointed out. This lack of necessity and determinism, where things are only accidentally connected, is on the part of things themselves and not just in thought. *Chance is thus as real as the indeterminism in those connections which we call accidental and extrinsic.* Chance and its opposite are as objective as the indeterminate and determinate connections we find in our cosmos. The world before us is not wholly necessary and fully determinate in its causalities. The disconnectedness between being a builder and having those other qualities which are only accidental to the art of building is hence not just a discrepancy in our knowledge. Chance thus is as real as the indeterminism between the essential and the accidental in nature itself; it is as real, for instance, as the indeterminism or lack of connection between being a builder and being a musician. Hence, if chance is a matter of human ignorance, this ignorance is sometimes occasioned by a disconnectedness in the structure of nature. The ignorance results from genuine discrepancies between the essential and the accidental on the part of things.

c. *How chance is a cause*

Unlike the house whose proper cause is a builder and unlike the oak tree whose proper cause is an acorn, chance events result not from one cause but from several, and while the builder is ordained to the building of a house and the acorn toward the production of an oak tree, there is no such order between cause and effect in those events that are caused by chance. Consider two old friends *A* and *B* who have not seen each other for years but who, on meeting in a hotel lobby, ascribe their encounter to chance. *A* is in the lobby in order to check his expenses; and *B* is there, let us say, to meet a business client for lunch. There is an order between *A*'s presence in the lobby and his concern with expenses and another order between *B*'s presence in the lobby and his business luncheon. The two orders intersect and we assign the cause of the intersection of chance. This intersection of the two orders is not itself an ordered event, i.e., flowing from a determinate and necessary cause. Rather, it is an accidental adjunct to the two lines of causality, in which each follows out its proper order and in neither of which is the meeting essentially included. In the case of a cow struck by lightning, a similar collision of two lines of causality can be discovered. The lightning tending to the ground is obeying its own proper order of causality; and the cow, grazing in the pasture, is likewise pursuing its own proper end or goal. The two orders of causality, neither of which intrinsically includes the other, crisscross with one another, and the resulting death of the cow is by chance. *This lack of a determinate order between the lines of causality is the causality of chance.*

Chance involves at least two orders of causality[14] in which there is no order of one to the other; both aim at some purpose other than the event which actually transpires. Many physical things result from several causes that are ordered to each other. The most obvious case might be that of an animal which is the result of at least two causes, namely the parents. However, such events are not said to be by chance. The causes are essentially ordered to each other. Chance, as a cause, is that lack of ordination between two causal orders.

As not being ordered by the essential character of any line of natural causality, an event produced by chance has an indeterminate and disconnected causality. The concurrence of the two sequences to produce in the one case the meeting of two friends and in the other case the death of a cow does not have a determined cause.[15] Nature ordains the food habits of a cow but not the death of a cow through a lightning bolt. Once the two series of events are under way — the two series involving in the one case the lightning and in the other case the cow — an observer from events already in motion could in principle foresee that collision of the two series which is ascribed to chance. But when all is said and done, there is no proper reason why the series started toward each other in the first place. It is this lack of necessary relationship between the causes of things which spell chance. This undetermined causality in the physical world is what constitutes chance as something objective rather than a mere case of human ignorance.

d. Chance and mathematical physics

This may be the place to stress that a physics, like Newton's which restricts itself to the mathematical aspects of the cosmos, will never by itself be able to distinguish between what is by nature and what is by chance. A mathematical physics is quite limited in dealing with relative and hence accidental motion, whether it be chance motion or not. In relation to the shore, a man walking toward the stern at

[14] *Summa Theologiae,* I, q. 115, a. 6.

[15] *Summa contra Gentiles,* Bk II, ch. 86; *Summa Theologiae,* II–II, q. 96, a. 6; I, q. 15, a. 6; *Commentary on the Physics,* Bk. II, les. 10, n. 234. Cf. also C. De Koninck, "Reflexions sur l'indéterminisme," *Revue Thomiste,* n.s., XXI (1937), 227–252, 392–409, esp. pp. 242–243 and Y. Simon, *Prévoir et Savoir* (Montreal, 1944), p. 26. For examples of how chance has influenced the shape of history, cf. L. Foley, "Chance and the Fortuitous in a Philosophy of History," *The New Scholasticism,* XXII (1948), 298–311.

four miles per hour on a vessel moving forward at the same rate is motionless. Such is the conclusion of a purely mathematical physics.

However, when regarded from a strictly physical viewpoint, the man may be said to be in motion in a manner natural to him, i.e., he is walking. No matter what our mathematics says about his rate (a mathematical attribute) of motion, it remains a fact that he is walking, an attribute that is physical and natural for him. Briefly put, the distinction between walking and locomotion in general is a physical one; it cannot be made in the perspective of a merely mathematical physics. In terms of another example, where a leaf is turning green while waving in the wind, there are, once more, two motions that from a physical point of view are only accidentally related; however, from the viewpoint of a purely mathematical physics, there is no basis for saying, as we have actually been saying, that each motion has an essential order within itself but is related to the other motion in a manner that is only accidental. *Unable by itself to distinguish the essential and the accidental in the mobile world, mathematical physics by itself is unable to discuss the problem of chance.*

e. *Chance and final cause*

Another way of stating this conclusion is to say that an approach to nature, from a mathematical or metrical point of view, does not consider the final causes or purposes of things, and because it must neglect final causes,[16] it cannot differentiate between events that are intended and those which are not. Mathematics rightfully takes no interest whatsoever in finality. Its subject does not require it to do so. There is no purpose to a triangle, no goal to the number 5. Whatever necessary truth such quantities may embody, the question of purpose simply does not apply to them. For a metrical or mathematical approach to nature, the meeting of our two men *A* and *B* is simply the point where two lines on a graph intersect; a similar conclusion holds for the relation between the two causal series of the grazing cow and the bolt of lightning.

But from a point of view more fundamental than mathematical physics, we have seen that we must know purpose in order to ascribe an event to chance. In a chance event, one thing is expected and something else happens.[17] *A* went to the hotel lobby to check expenses and *B* went there for a luncheon. Something not

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[16] *Summa Theologiae,* I, q. 5, a. 4, reply 4; *Commentary on the Metaphysics,* Bk. III, les. 4, n. 375.

[17] *Exposition of the Posterior Analytics,* Bk. II, les. 9.

determined by either of these purposes takes place, the meeting of the two friends. It is necessary to understand that there is purpose in a sequence of events in order to recognize that there are events not determined by purpose and therefore accidental.[18] The lightning was acting for its goal, to neutralize itself; and the cow was seeking its own end also. The collision of the two series of events must be more than a point on a graph if a proper distinction is to be made between what is essential within each series and what is accidental between one and the other. *Hence, it may be concluded that mathematical physics by itself must ignore the meaning of true chance. And the reason why it does is this: mathematical physics, as mathematical, does not take account of purpose to which chance itself is related in reality as well as in our understanding of reality.*

III. CHANCE AND INDETERMINISM

a. Chance is not a primary cause

If, because of the reality of chance as a form of disconnectedness, radical determinism cannot be accepted as an account of order in the physical world, radical indeterminism merits a similar rejection. By way of justifying this conclusion, let us evaluate the arguments for indeterminism as they emerge out of biology and physics.

In Darwin's theory of evolution, changes from one form of life to a higher one are allegedly brought about by slow accidental variations. The tendency to such variations is said to be a basic characteristic of life or, in the language of this book, a first principle of living things. In ascribing the evolution of living things to slow accidental variations, Darwin made chance a fundamental cause within the living world.

But chance, while real, cannot be the primary causality in biological evolution where such evolution truly took place.[19] Chance can exist only where there is a previous purpose or order. If *A* in our example did not intend something other than his encounter with *B*, we could not call this encounter accidental; if the cow were not engaged in the pursuit of food and hence "intending" something other than being struck by lightning, there would be no meaning to ascribing to chance its death by a lightning bolt. *In short, events that result from chance, however numerous they may appear to be, must always be a secondary kind of reality because they are a deviation from an order which is more primary.* One thing is "intended" and some-

[18] *Commentary on the Physics*, Bk. II, les. 15, n. 263.
[19] *Summa contra Gentiles*, Bk. II, ch. 39.

thing else happens. Without a previous intention or order that chance changes, there could simply be no chance. Chance is relative and secondary; it cannot be the absolute and primary cause of all biological change. Without the more primary order which it modifies, chance could neither be real in itself nor be identifiable by us.

b. Random aggregations

In addressing the problem of indeterminism, as arising out of the physics of radioactivity, thermodynamics, and quantum mechanics, it will be vital to make a distinction between chance and what can be appropriately termed randomness.[20] In order to show what this difference is, let us take a familiar example of a statistical whole — a barrelful of variously colored beans mixed so long and so thoroughly that the units of different colors are arranged in some kind of uniform pattern throughout the container. *Such a uniform distribution of units in a whole is called random distribution. Beans of different colors are evenly or homogeneously scattered throughout such an aggregate.*

Let us further assume that from the known dimensions of the barrel and the known size of the beans, the number of beans in the whole aggregate can be calculated to be 100,000. Let us suppose, finally, that upon drawing by appropriate means a fair sample of the beans, say 1000 of them, we find that there are 600 white beans and 400 black ones.[21] From such a sampling, it can then be predicted that in the whole barrel there are 60,000 white beans and 40,000 black ones. However, such a prediction holds for the total aggregate; the color of any one pick can be predicted only with probability. (Probability in this sense should not be confused with probability as related to dialectic.) Even when we know the ratio of white beans in the whole to black beans in the whole, only probable predictions can be made of individual picks. Thus, at any one time, the probability of picking a white bean is 6/10 or 3/5 and the probability of picking a black bean on any one occasion is 4/10 or 2/5.

In a highly simplified and absolutely ideal form, this is an ex-

[20] According to one theory of probability, a random distribution of the members of an aggregate may be regarded as one in which there is a constant relative frequency, "If a certain result occurs m times in n trials, we call m/n its relative frequency." R. von Mises, *Probability, Statistics, and Truth* (New York, 1939), p. 157.

[21] "The fundamental tenet of a frequency theory of probability is then, that the probability of a proposition always depends on referring it to some class whose truth-frequency is known within wide or narrow limits." J. Keynes, *Treatise on Probability*, p. 101.

ample of statistics. It enables us to see the kind of condition which is necessary in a statistical problem, and what statistics does and does not say about the problem of determinism.

The homogeneous or evenly distributed pattern of the beans, after a long process of mixing, would be said to form a random distribution. But randomness is not the same as chance. For a homogeneous distribution, like that of our beans in the barrel, is truly an ordered collection. There is an order of a different kind from the one that experience usually reveals and that we normally study in our sciences, but there is order and pattern nevertheless.

c. *Randomness and chance*

Our conclusion on this point can be confirmed by the fact that it is possible to make a mathematical analysis of a random collection. The order found to exist in the whole proves that there is an order among the individual parts even when we are unable to trace out the order itself. Statistics can be applied only to the extent that the material studied has an order.[22]

Randomness is open to scientific analysis; but chance, as such, is not. Randomness involves the mathematical; but chance is physical. Chance is a real disorder; but randomness is a disorder only for our logic, accustomed as it is to the non-statistical methods of solving problems. *As a sign of its difference from randomness, chance can interfere with a random collection and thus introduce a real, physical disorder;* for example, when the sampling process is interrupted and the one counting the beans leaves the room temporarily, birds or other animals could invade the bean barrel and eat an appreciable quantity of the beans, thus producing a chance disturbance of the random aggregate. Chance therefore can affect a random connection; this shows a considerable difference between chance and randomness. Randomness is a type of order which consists in indifference or homogeneity.[23]

Those who interpret modern atomic physics as evidence that the world is disordered and chance-like reverse the logical direction for approaching nature. To ask whether order exists in nature is one kind of question; what that order is in its more precise detail is another problem which, if our previous analysis is correct, occurs after the

22 "Whence, the existence of statistical laws is impossible without the existence of non-statistical laws." F. Northrop, *The Logic of the Sciences and the Humanities* (New York, 1947), p. 218.

23 This is another way of saying with Hume that the members of a random aggregate have "equal chances."

first kind of question. On this basis, the failure in the second problem to find the exact contours of the order in nature does not necessarily deny our answer to the first question, namely, that there is order in nature to begin with. If the universe as revealed to us through analyzed common experience is truly ordered, there must somehow be an order among its parts even when the parts are microscopic. For order does not spring from chance; rather chance is something secondary and relative to an already existing order. Only thus can chance be; only thus can it be understood.

IV. ARGUMENTS AGAINST FINAL CAUSES

a. An historical note

The final cause is that for the sake of which something is done, and of all the essential causes which Aristotle claimed existed in nature, the final cause is the most disputed and denied. At the very beginning of the modern period, René Descartes (d. 1650) proposed that the mind give up its search for final causes. He did not openly deny final causes or purposes in nature but held that it was hopeless to seek such causes in physical science because to do so would be to pretend an insight into the infinite and "inscrutable" counsels of God who planned our world into existence. Here are Descartes' own words:

> Already knowing, as I do, that my nature is extremely weak and limited and that the nature of God is immense, incomprehensible and infinite, I have no difficulty in recognizing that there is an infinity of things in His power, the causes of which transcend my powers of understanding. This consideration alone is sufficient to convince me that the species of cause which we term final is not applicable in respect of physical things; for, as it seems to me, we cannot without foolhardiness inquire into and profess to discover God's inscrutable ends.[24]

Hence, while not denying that final causes exist in nature, Descartes claimed that because of the infirmity of human reason we cannot know what such causes are; the claim to know what God had in mind as the purposes of natural things would, as we read above, "profess to discover God's inscrutable ends." *Actually, as we shall see, Descartes proposed a view of the world that really leaves no place for final causes.*

From Descartes' time down to our own, final causality has lost the eminence it once commanded as not only a cause but indeed *the* cause of all else in nature. Purpose is now no longer considered

[24] Meditation IV, in *Descartes: Philosophical Writings,* transl. N. Kemp Smith (New York, 1952), p. 234.

as a principle in material things. Most views of the material world in the nineteenth and twentieth centuries would agree with Immanuel Kant (d. 1804)[25] that, although purpose plays a role in the conscious deliberation of human beings — for example, they go to school for the purpose of learning — it is illogical to conclude that there are similar plans or "intentions" in the subhuman world. Most philosophers since have shied from the concept that there is purpose in nature, because they think that purpose implies consciousness and deliberation in the things that act for ends.

b. Mechanism: Examples

The most popular substitute for final causality in explaining things is mechanism. "The world," said Descartes, "is a machine in which there is nothing at all to consider but the shapes and movements of its particles."[26]

Let us see how a mechanist explains the order in the world about us. According to Lucretius, a famous mechanist of the ancient world, "Our members have not been made for our use; on the contrary, we have used them because we found them made."[27] Here is a direct clash of mechanism and final causality. The finalist will claim that our hands and our feet have each been made for a purpose; our hands, for instance, were intended to make things like food, clothing, shelter, etc., and because of this purpose, they were endowed with the structure we observe in them and they were placed at our sides in order to have a freer movement than the forelegs of animals.[28] *But by contrast to this view in terms of finality, the mechanist says, with Lucretius, that we proceed to use hands for purposes of making things, because they happen to have their given structure and position, and finding them so, we use them for our work.* The use simply follows upon the structure of the hands; it was not intended prior to the hands as the purpose for which they were made.

c. Arguments for mechanism

There are several arguments in favor of mechanism:

1. *In the first place, it would look as though we must endow matter with intelligence in ascribing purpose to nature.* The finalist will argue that there is purpose in the development of the human embryo, in the cycle of the seasons, in the relation of animals and plants to

[25] *Critique of Pure Reason,* transl. N. Kemp Smith (New York, 1933), pp. 521–522.

[26] *The Principles of Philosophy,* P. II, n. 36.

[27] *On the Nature of Things,* Bk. IV, line 22.

[28] *Summa Theologiae,* I, q. 91, a. 3.

their environment, in the movements of the stars, in chemical and physical change — in short, there is purpose or plan wherever there is order. But to see nature as purposeful might be to ascribe to matter the ability to plan the attainment of its goals like a reasonable creature. Where purpose exists, an intelligent planner would seem required; and far from showing evidence of being intelligent, the subhuman world, even the plants and animals, presents an utter lack of intelligence. Since matter is not intelligent, it would seem illogical to claim for it purpose or goal, i.e., finality.[29]

2. *As another argument in favor of mechanism, there is the dazzling progress made by physical and biological studies after they decided to ignore final causes.* According to Newtonian physics, for example, the world seemed explainable by the mechanistic concepts of mass and acceleration with no appeal to final causes whatsoever.[30] Even biology has seemed to push deeper and deeper into the structure and function of living organisms by regarding the organisms themselves in the spirit of Lucretius. In the light of the success achieved by those modern methods of investigation which ignore final causes, these causes would seem to be unnecessary in order to explain our world.

3. *Another kind of evidence in favor of mechanism is the occurrence of disorders in nature such as tidal waves, earthquakes, or typhoons.* If nature acts for a purpose, how can such disorders and even disasters be explained?[31]

In their scheme to explain the cosmos, mechanists always invoke the material cause and very often the agent. But whatever else they say about causality, mechanists refuse to admit the existence of final causes in nature. *That is why we may characterize mechanism simply as an attempt to explain the world without recourse to final causes.*

V. PROOFS FOR FINALITY

a. No natural motion is indifferent to its result

From the viewpoint of a nominal definition, the final cause of a thing has three characteristics: it is that for the sake of which a thing

[29] This is why I am not using the otherwise respectable term *teleology* which somehow connotes consciousness to modern man. A number of modern biologists are willing to acknowledge purpose, at least in the living world, but prefer to speak of teleonomy. Cf. C. Pittendrigh, "Adaptation, Natural Selection and Behavior," *Behavior and Evolution,* ed. A. Roe and G. Simpson (New Haven, 1958).

[30] Final causality has no place in mathematical physics. But Newton's fellow countryman, Francis Bacon, ruled it out from all science; "The final cause corrupts rather than advances the sciences." *Novum Organum,* Bk. II, ch. ii. Elsewhere Bacon calls final causes "barren." *The Advancement of Learning,* Bk. II, p. 142.

[31] *Commentary on the Physics,* Bk. II, les. 13, n. 262.

acts; it is the good of the thing acting; it terminates the action so that the agent in question comes to rest.[32]

To satisfy hunger is a final cause of eating; knowledge is the goal of the human intellect. A house is the end of a builder; health, of the art of medicine; a statue, of a sculptor. In all such examples, drawn from a world very close and hence familiar in our experience, the agent acts for an end; the end is the good toward which the agent tends; and the agent, on reaching this end, terminates there by bringing his series of actions to a close. Such examples from the world of human affairs are not proposed as proof for final causality in the natural world. They are rather intended to show the meaning of our term final cause.

Our next task is to prove that nature acts for an end, i.e., that all mobile being is following out a purpose or a plan and not obeying only blind mechanical forces and factors like those which produced the "members" in the example of Lucretius. Argument for the principle of finality in nature, like many other arguments in our general science, is dialectical in character and aims at the inductive knowledge that final causes exist. There are at least four dialectical arguments toward the inductive principle that nature acts for an end.

For the first argument, let us listen to St. Thomas Aquinas:

> Were an agent not to act for a definite effect, all effects would be indifferent to it. Now that which is indifferent to many effects does not produce one rather than another. Therefore, from that which is indifferent to either of two effects, no effect results unless it [the agent] be determined by something to one of them. Hence it would be impossible for it to act. Therefore every agent tends to some definite effect which is called its end.[33]

St. Thomas is proposing here that when an effect (repeatedly) follows from a given cause, we attain a sufficient reason why this is so only when we admit that the cause was ordered to produce the effect in question. If *B*, an effect, repeatedly follows *A*, the agent, we are justified in concluding that *A* is determined to produce *B*; for if *A* were indifferent when acting (and hence not determined to produce *B*) there would be no sufficient reason why *B*, rather than something else completely different, should repeatedly follow from *A's* actions. *Anything indeed could follow from the action of an agent if that agent were not ordered or determined to produce this effect rather than that.* The burning of wood, for instance, repeatedly pro-

[32] *Commentary on the Metaphysics,* Bk. I, les. 4, n. 271.
[33] *Summa contra Gentiles,* Bk. III, ch. 2.

duces ashes and not something else. This repeated result can be explained only if we concede that the wood, far from being indifferent to what is produced, is ordered to produce ashes under the given conditions; for if it were not so ordered and if it were indifferent to its effects, there would be no sufficient reason why ashes should always result from the activity of burning and not some completely different kind of thing.

Mechanists, of course, would agree that an agent is determined to produce its effect. Paper, it would be said, is determined under proper circumstances to produce ashes and an egg to produce a young bird. But these (mechanistic) answers beg the question. Where an agent, e.g., paper or an egg, is determined to an effect, the determination to the effect is not itself a cause but something that we have to explain. Such determination is not another agent cause but precisely a datum that must be accounted for. The final cause is not another quasi-agent cause, as Descartes would have said, but the very determinant of the agent, the cause of the agent's activity, the correlative to it. Agent and final cause are two moments of one effect, the one accounting for the production of the effect and the other accounting for its determination to be this rather than that.

Let us look at the following syllogism, which for us is dialectical: Whatever in nature occurs always or at least for the most part happens either by chance or for an end. What occurs in nature always or for the most part does not happen by chance. Therefore, such happenings are for an end.[34]

This syllogism is disjunctive. Moreover, it has contradictory alternatives so that when one alternative is denied the other can be affirmed. The burden of the argument is to employ induction for securing the minor premise: what happens always or for the most part in nature does not happen by chance. Our project requires us to admit that chance does not give a sufficient reason why one event rather than another should follow from a given action. And if chance is inadequate to explain why one event follows repeatedly from another, then we are obliged to conclude that only an end or goal can provide our adequate explanation. In other words, if chance cannot explain why this effect rather than some other one is repeatedly produced by a given agent, under the same circumstances, then we have achieved at least one proof of our principle that nature operates for an end.

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[34] *Physics*, Bk. II, ch. 8, 198b, 35–199a, 8; *Commentary on the Physics*, Bk. II, les. 13, n. 256; *Summa contra Gentiles*, Bk. II, ch. 6.

Chance, or the undetermined causality,[35] does not give an adequate account of an effect that occurs frequently from the action of a given cause. To say for instance that the hatching and growth of young birds was not "intended" by the actions of the parents in the period preceding the laying of the eggs would mean that the parental actions, e.g., the formation and fertilization of the eggs and the building of the nest, did not "aim" at the birth and growth of the young. The hatching and subsequent history of the young birds would, on this supposition, have to be passed off as "unintended" and hence as the accidental result of the reproductive actions of the parents. Such actions by the parents would have to be considered as "indifferent," in the language of St. Thomas, to the outcome which actually results, indifferent, that is, to the hatching and growth of the young.

Now to say that the circumstances preceding the birth of young sparrows are indifferent to that birth and to say that such a birth is not intended by these preceding causal circumstances fails to do justice to the facts to be explained. The birth and growth of young birds rather than the production of some other effect repeatedly follows the reproductive actions of parents, and the only reason by which this can be explained is to admit that there is purpose,[36] ordering the agent causes toward these effects and not toward some other effects. In other words, the parental actions of sparrows are ordained to the reproduction of their young, which is the final cause of those actions.

It would surely be considered absurd if one went about claiming that by coincidence a sparrow built a nest, by another coincidence it laid eggs that had been incidentally fertilized, by another coincidence the eggs were incubated, and by another whole series of coincidences the little birds were hatched, fed, and pushed out of the nest to fly. Common speech shows that no one could take such an analysis very seriously. When an event like the hatching of eggs occurs not just once but frequently as a result of the same kind of causal actions, it is surely necessary to assign a reason for such frequency of occurrence. To claim that by coincidence a sparrow is hatched after the series of mating and nesting actions have been completed would not explain the birth of even a single sparrow, let alone an immeasurably great number of such processes. For when we assign an event to chance or coincidence we are not explaining it; we are saying that it has no explanation. Repetition is an order or determination; it

[35] *Summa contra Gentiles,* Bk. II, ch. 86.

[36] *Summa Theologiae,* I, q. 2, a. 3.

cannot be explained by assigning causes that are indifferent or indeterminate, i.e., causes that are chance.

While it seems absurd to attribute the orderly and even repeated reproduction of sparrows to the action of chance or coincidence, it seems quite natural and normal to ascribe to chance such events as the death of the nestlings because of a bad storm or because of the visit of a neighborhood cat.

Our ordinary language bears evidence that very early in its notions of the material world the human mind distinguishes between such things as the normal reproduction of sparrows and the abnormal interference with that process. Anyone who would deny this distinction would be questioning that general knowledge of nature which is more certain than any more precise and more particular notions which would repudiate finality in nature.

To sum up what may seem to be a rather long and complicated argument, where an event happens always or for the most part from the same cause or causes, we cannot attribute that event to chance. In other words, where *A's* action in the same circumstances always produces *B* as an effect, it would be illogical to say that in these circumstances *A's* action is always indifferent to which effect it produces. On the contrary, the conclusion is imposed that *A* is determined or ordained to produce *B;* in other words, there is a purposeful rather than indifferent arrangement (which is no arrangement) leading from *A* to *B*, from the mating actions of sparrows to the birth of their young and from the burning of wood to the production of ashes. In fine, since the repeated occurrence of an event cannot be the result of chance, which is indeterminate causality, it can only be the result of that determinate causality which is purpose or end.

b. In any completed series, one part serves another

A second approach to finality in nature can be best achieved by setting forth, and then proving, the proposition: *In any completed series of actions the prior members of the series are for the sake of the later or posterior ones,*[37] *for this is really another way of saying that there are final causes in nature.* But, as dialecticians, let us begin not with natural things like sparrows, from mating to the first flight of their young, but with the more familiar world of art and the series of acts producing it.

[37] *Physics,* Bk. II, ch. 8, 199a, 9 ff.; *Commentary on the Physics,* Bk. II, les. 13, n. 257.

In the building of a house, there is a definite order: one stage not only comes before another but is ordered to that other. The foundation is laid first so that the walls will have a proper footing; and the walls are made at least in skeletal form before the roof so that the roof can be put where it properly belongs. In the carpentry of the walls, spaces are left not only before the windows are inserted but because the windows are to come. Houses would not be what they are unless the prior stages of the construction work were not only before the later stages but for the sake of them.

Now nature reveals an order of the prior to the posterior which may be compared to the order which we observe in building. A study of the reproductive activities of sparrows would confirm this proposition. Natural things reach their perfection by a gradual process because they are all mobile beings, and in the step-by-step realization of their fullness, the preceding stages of development serve the stages to come later. In the development of embryos, it is apparent that one phase not only goes before another but prepares for it. The storage of food by squirrels prior to cold weather is ordered to their future wintertime subsistence as, by comparison, one part of a house is ordered to another part that will be built later. Spring not only precedes summer and its harvest but prepares for it.

One of the most remarkable indications of purpose in nature is the strange behavior of water chilled to 4 degrees Centigrade; when it cools to this point, it does something which other liquids do not do; it expands. Thus expanded, the cooler water becomes lighter and rises to the surface, and because such cooler water is near the surface as the freezing point is actually reached, water freezes from the top down. If at 4 degrees Centigrade, water did not reverse the tendency of liquids to contract when chilled, the cooler water would always be at the lowest level of the container, and water would freeze from the bottom up.

Now why does water, when near its freezing point, suddenly reverse the behavior characteristic of liquids that are cooled? For such a phenomenon, there is no complete explanation without appeal to the final cause of preserving the fish life in the world. If water froze from the bottom of its container, our streams and lakes in colder climates would be frozen solid in the winter, and all life in such climates that depend on running water would perish also. The activity of water at 4 degrees Centigrade is thus a crucial fact in preserving all of the higher forms of life outside the tropics. At 4 degrees Centigrade, water, like the man building a house, seems to be arranging (though obviously without consciousness) for another event.

Now the mechanist confronted with the facts about the behavior of water at 4 degrees can hardly say anything except a vague Lucretian: "It just happens that way." What else could be said unless it be admitted that there is a purpose or final cause for this strange behavior of water? The mechanist has to treat the expansion of water when it approaches its freezing point as a coincidence in the cosmos, and all other events which depend upon this phenomenon, such as the preservation of aquatic and even terrestrial forms of life, must likewise owe their survival to a freak. But to characterize this behavior of water by claiming that "it just happens that way" is hardly an explanation for the phenomenon; it is a begging of the question. For an explanation of the series of events that goes from the activity of water at 4 degrees Centigrade to the preservation of life beyond the tropics, the mind must turn to final causes.

The behavior of water is not the only fact uncovered by modern research to prove that, in a completed series of events, the earlier parts of the sequence are for later ones. On many counts, modern physical and biological investigations of nature have enriched our evidence that things are ordained to other things — sunlight to the process of photosynthesis, plants to animals and animals to plants in their respective respiratory processes, minerals to living things, and parts of the mineral world to other parts. Modern research has taught us more than any previous investigations how things act for the good of other things. It has reinforced the age-old conviction of men that nature operates for an end.

c. *Art operates for an end*

The third argument for finality in nature is again taken from human art which we have previously found to be one of our best dialectical springboards to get into the nature of things. The reason for this is that art is so familiar. Our argument can be summarized as follows: *Art acts for an end, and because art is an imitation of nature, nature must also be acting for an end.*[38]

Perhaps this argument sounds somewhat naïve. It looks as though we are conceiving the world entirely on the scale of human art. There may be strong evidence here of anthropomorphism, the tendency to conceive of everything not as it truly is but according to

[38] *Physics,* Bk. II, ch. 8, 199a, 18–20; *Commentary on the Physics,* Bk. II, les. 13, n. 258.

our own image and likeness as artists and hence as having purpose in our work.

But despite its apparent naïvete, our present argument is one of our best defenses of final causality in nature. In the first place, art in all of its various forms must rely upon a steady order in the world of nature. The aeronautical engineer, designing an airplane, cannot look upon his materials as being a mere meeting ground of coincidences. He does not, for instance, regard the aluminum planned to become a fuselage as a metal freakishly changeable from being hard to being soft, as a thing that tends to go upward one minute and down the next, as a substance with no fixed electrical characteristics. On the contrary, the design engineer of airplanes discovers in aluminum an order to fixed kinds of ends, to presence on earth for instance when not hindered by a heavier body and to a constant electrical conductivity. Since such characteristics of aluminum are constant, they are not merely coincidental. Aluminum is essentially related to them. It is ordered to them, and the airplane designer discovers that he can count on this order in making his final product. From the crudest cutting or pounding tool to the most complicated airplane or electronic device, even to earth satellites, the manufacture of anything in the way of art depends upon the order of the material to fixed ends. The artist always in some way discovers an order in nature and turns it to his own use. Without that order on which art must count, art itself would be impossible; and because of that order which art reveals in what it works with, the materials in art can be seen to have a final cause. In other words, nature acts for an end.

The same argument can be given a different turn if we reflect on what an artist does to his natural raw materials. Arts that cooperate with nature, like medicine and farming, show that nature acts for an end; for there could not be cooperation between art and nature unless both the art and the nature were acting for the same end. If art acts for an end and if the arts that cooperate with nature do nothing but help nature along, then the nature must also be acting for an end. Moreover, even in the case of the arts that add to nature, art — always an imitation of nature — brings to "completion" an order in nature which is unable to "complete" for itself.[39] The electric lighting systems, in our homes and elsewhere, capture motions already existing in matter and bring them to a "perfection" which by themselves they could not attain. What is merely brought to a certain "perfection" or "completion" by art must exist incipiently

[39] *On the Power of God,* q. 3, a. 8, reply 5.

and imperfectly in the raw materials with which the artist works. Action for an end in the case of art exists only more apparently and more completely than it does in the raw materials. Now even incipient and imperfect action for an end in the raw materials of art is still action for an end. If nature inchoately acts for ends that art finally achieves, then nature acts for ends.

Art, it was observed earlier, is never pure art. It always requires natural components, and upon such natural components it depends for whatever being it has outside the mind. If the activity of a machine is for an end and the machine depends on the materials, then the endlike action of the materials must be even more fundamental than the endlike action of the machine as a whole, even though we may not see it as well. That art acts for an end is evident even though it is derivative; that nature acts for an end may be less evident to us but in itself it is more basic.

d. Evidence among animals and plants

Like the rest of the arguments for finality in nature, the fourth approach is destined to lead to the induction that nature acts for an end. The present argument concerns the behavior of animals. Such behavior has impressed men so forcefully not only in primitive but also in civilized society that animals have sometimes been considered intelligent creatures.[40] This is especially true in the case of animals like ants, spiders, bees, birds, and household pets. Spiders spin their webs with a skill comparable to the dexterity of human weavers. Ants on the one hand and bees on the other work together as a group almost as though, like rational animals, they were capable of planning a truly social life. The migration of birds, not to mention the architecture of their nests, has always filled men with wonder. Libraries teem with books on the remarkable behavior of animals, and even today, while aware of the wonderful habits of the animal world, we usually marvel at their causes. *The evidence is compelling that animals act for an end.*

But, however astonishing the behavior of animals may seem to us, men alone in our natural world are truly intelligent beings. For the work of animals, though remarkable, does not show the variability which intelligence and freedom can introduce into the work of man. The nests of the various species of birds, the dams of beavers, the webs of various kinds of spiders, and other such products of the

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[40] *Physics*, Bk. II, ch. 8, 199a, 20–30; *Commentary on the Physics*, Bk. II, les. 13, n. 259.

animal world are always the same in the case of the same species of animal. Swallows, for example, have been building their nests in the same way for as long as swallows have been known to man. Even David Hume could remark:

> All birds of the same species in every age and country, build their nests alike: In this we see the force of instinct. Men, in different times and places, frame their houses differently: Here we perceive the influence of reason and custom.[41]

It is evident that animals act for ends. But they are only ordered to goals. Unlike man, who has intelligence and freedom, they do not order themselves or they could vary the order. Man is such a master of his work that he designs it for himself and, designing it, can vary it. Animals thus are not rational but strictly natural creatures; however, their behavior, as witnessed by men of all times and places, shows that what is natural acts for an end or purpose.

Even among plants there is a remarkable order which yields evidence of design and purpose. Here, too, it can be established by a clear induction that nature is ordered to an end. In the case of trees, for instance, from the roots where water and minerals are absorbed all the way to the leaves where photosynthesis takes place through sunlight, there is a unity in variety which we call order; many structures and functions conspire toward a unified goal, the good of the plant. The behavior of plants no less than the activity of animals provides ample inductive evidence that nature operates for an end.

In the living world, purposes of organisms and of organs can often be more or less clearly identified. This is not so in the mineral realm; though we know there is purpose there because there is order, we cannot name the purpose of this or that thing, except perhaps in such rare cases as the behavior of water at 4 degrees Centigrade.

VI. REPLY TO OBJECTIONS

a. Chance events prove finality

Not all of our arguments for final causes are of equal weight. They are, of course, dialectical in character, and the reader can take his pick among them. The important thing is the induction to which our dialectic leads.

There is a sense in which finality can be established by responding to the objections which are raised against it.

[41] *An Inquiry Concerning the Principles of Morals* (New York, 1957), p. 35.

One obstacle to the acceptance of final causality in nature arises from monsters and freaks: animals that are born with deficient organs, plants that are stunted, tornadoes and tidal waves, earthquakes and landslides, and many other phenomena of a less spectacular nature. If nature is truly planned, how can there be abnormalities? The existence of monsters and freaks would seem to argue that nature is unplanned and hence without purpose. In other words, nature does not seem to be operating for an end.

In order to meet this difficulty, strength can be drawn once more from the familiar and even homely world of art. Everyone admits that art operates for an end— the grammarian, for instance, in order to express thought, the doctor in order to heal the sick, and the mechanic in order to repair a car. If there is one thing that all artists, good and bad, have in common, it is the fact that they act for an end.

But in spite of action for an end, every artist can make mistakes. The grammarian can mispronounce or misspell a word, and the doctor can make a wrong diagnosis or prescribe a wrong medicine. Action for an end, therefore, does not rule out abnormalities. In a similar way, nature can act for an end and still allow those abnormal events that we ascribe to chance. The objection that abnormalities in nature prove that nature cannot be acting for an end fails to establish its conclusion.[42]

In fact, the present objection to the principle that nature acts for an end is a proof for the principle itself. *Indeed, if the artists like the grammarian or the doctor were not operating for an end, it would be impossible to recognize mistakes in their art.* A word, for example, is a kind of end to which a concept or idea must be ordered to be properly expressed. The sound that represents the concept *man* must be correctly pronounced by the good grammarian if the sound is to fulfill the end of the grammarian's art; if the word is mispronounced until it sounds like *main* rather than *man,* the grammarian has not fulfilled his aim in using an expression for man.

Now it is only because the grammarian ought to be using one sound, like *man,* but uses another, like *main,* that we can accuse him of an error. It is only because he is acting for an end and fails to attain it that we can speak of the abnormal in his art. Hence, in order to speak about mistakes and shortcomings in any art, there must be a previous awareness that the art is acting for an end.

In a similar way, deviations from the course of events that nature

[42] *Commentary on the Physics,* Bk. II, les. 13, n. 263.

follows for the most part do not prove that nature acts without an end or purpose. They prove in fact the exact opposite. *Recognition that there are aberrations in nature is a sign of our conviction that nature is acting for an end.* How could there be a disorder in nature unless there is an order which normally occurs and is somehow interrupted by the event that we attribute to chance? Earlier in this chapter it was argued that chance, though real, is something secondary; it presupposes the existence of at least two series of events, both ordered within themselves and somehow crisscrossing each other. Evidence that there is chance in nature is an argument that there is order prior to chance. As the mistakes of art can be identified only because the art operates for an end, so the abnormal events in nature, far from showing nature to be purposeless, are signs of purpose itself.

b. Mechanism does not explain order

A second objection to the proposition that nature operates for an end is the very success of mechanism, as a project to explain the world in terms of matter and the agent, with no apparent reference to final causality. In our example of hands, which, Lucretius says, are found to be as they are and are used by us because they happen to have the structure and position we observe, function is the mechanical result of structure rather than a final cause of structure. Though mechanism may be losing ground in contemporary physics as well as in recent biology, it has scored amazing successes without appealing to final causes.

Yet mechanism cannot be accepted as a realistic account of matter or life. To view the world in terms of impressed forces only is to suppress the very reality of nature itself. If mobile being is the result of external mechanical forces alone, there is no intrinsic principle of motion original to each kind of material thing. A material thing, as mechanism sees it, must become a kind of zero point and all reality comes to things from outside them, without the contribution of that intrinsic principle which we call nature.

Let us look at the inadequacy of mechanism through the eyes of two great philosophers:

Plato, in his dialogue *Phaedo,* puts into the mouth of Socrates a telling refutation of mechanism. In order to explain why he is sitting in prison, a mechanist, according to Socrates, can do no more than describe the physiological fact that his muscles and nerves and bones are related to each other in such a fashion that he is occupying a sitting position in this place.[43] Such physiological principles, of course, are causes for the fact that Socrates is sitting in prison; but the most important cause of the imprisonment is overlooked. This cause is the purpose of his being where he is, e.g., serving time for the charge made against him. The mechanist does not get to the most important reason for the event being described.

Writing of those who deny final causality, Leibniz says:

> As if in order to account for the capture of an important place by a prince, the historian should say it was because the particles of powder in the cannon having been touched by a spark of fire expanded with a rapidity capable of pushing a hard solid body against the walls of the place, while the little particles which composed the brass of the cannon were so well interlaced that they did not separate under this impact, — as if he should account for it in this way instead of making us see how the foresight of the conquerer brought him to choose the time and the proper means and how his ability surmounted all obstacles.[44]

Just as purpose or end, e.g., his serving a sentence, is the reason why the muscles of Socrates were flexed to make for a sitting position, and just as desire for victory is the reason why cannons are made and used as they are, so there is a purpose or goal for the structures we find in nature. To measure structure in nature is to get at something real but to settle for only this is like accounting for Socrates' position by describing only his muscles. Structure is for the sake of operation.

The order in the universe, explored by system like that of Newton, is, like the sitting posture of Socrates or the position of cannons in a battle, an effect of the end. Indeed, only the effects of final causality can be measured. And any approach to nature which refuses to go beyond measurement cannot, of itself, argue to the existence of final causes, much less argue to their nature.[45] To take one example, let us look to the theory of universal gravitation. Mechanism would hold that gravitation between bodies is the force which holds the universe together. However, those who make the induction to final causality in nature may see gravitational tendency as the effect of the end. Gravitation as existing in all bodies may be considered a measure of the common tendency of all bodies to the unity of the universe.[46] It is in this light an effect of the end,

[43] *Phaedo*, 98; The Dialogues of Plato, transl. B. Jowett (New York, 1946), I, 482–483.

[44] Leibniz, *Discourse on Metaphysics*, XIX, in *Leibniz: Selections*, ed. P. Wiener (New York, 1947), pp. 319–320.

[45] *Commentary on the Metaphysics*, Bk. III, les. 4, n. 235.

[46] *On the Revolutions of the Heavenly Spheres* in *Great Books of the Western World*, ed. R. Hutchins and M. Adler, XVI, 521.

just like the sitting posture of Socrates or the firing of the cannon. If the unity of the universe is an end,[47] gravitation is a phenomenon required by the end. Without recognizing ends, we do not know the most important *why* of things, though in the mineral world such a cause is difficult to find. Yet our inability to find such a cause does not mean it is not there. Its presence is shown by the order, which is its effect.

c. Nature need not deliberate

Another difficulty against the view that nature acts for an end is that nature does not act in a truly deliberate fashion and, at the levels below animals, nature does not even act with consciousness. Man of course acts with free will, and because he can deliberately plan a course of action it is obvious that he acts for an end. But where deliberation is missing, hence in the subhuman and especially subanimal worlds, it would look as though action for an end is impossible.

Once more, in meeting this difficulty and in making our induction to the proposition that nature acts for an end, we can make dialectical use of the world of art in order to show our point.

It should be observed first that the better an artist the less deliberation there is in his work; and if an artist were truly perfect, he would not have to deliberate at all.[48] In learning to write, the little child at first makes a conscious and deliberate effort in every word and even every letter; but later on, as he acquires perfection in the art, he writes letters and words without deliberation and almost without being directly conscious of the process. In kindred fashion, when learning to play the piano a beginner proceeds very slowly and, once again, very deliberately — weighing his decision on almost every note and key. However, this approach in an accomplished piano player would be considered quite defective. Carrying our examples to the conclusion, we can hold that the ideal artist who can only be approximated by any human being, however great — whether an artist of words or notes or some other medium — would not deliberate at all because he would have perfect knowledge of the way to attain his goal. The perfect artist perfectly determines means to his end, whereas in the worker still growing in his art there is a more or less open and indeterminate grasp of the means, so that the artist must still pick and choose among them. There is no need to deliberate when the means to an end are determined.

[47] *Commentary on the Metaphysics*, Bk. XII, les. 12, n. 2627.
[48] *Commentary on the Physics*, Bk. II, les. 14, n. 268.

Now nature has determinate means to attain an end and hence it need not deliberate about them.[49] The fact that nature tends toward ends in a fully determinate but non-deliberating way is a sign that there is a perfect artist that is responsible for it. It is not a part of our science to prove, by the argument from design, that such an artist exists. It is urgent here only to remark that, if nature does not deliberate, the artist of nature has deliberated for it, as metaphysics can show.

Even human art is distinct from nature because such art has its principle extrinsic to the work while in nature the principle of a work is in the work itself. If an art, like shipbuilding, were intrinsic to the materials, ships would be made by nature itself, but since ships are not made by nature, we have to trace their cause to distinct and extrinsic principles, namely human reason. Just as we have to go outside of nature to account for the determinate means to determinate ends which we find in shipbuilding, so in an even more remarkable and perfectly indeliberate order of means to ends that we discover in nature, we must go outside of nature for our explanation. Just as we need a shipbuilder to account for ships, even more so do we need a perfect artist to account for the even more perfect ordering and certainly more basic order of means to ends that we find in nature. If nature, because it acts without the hesitancy and deliberation of an imperfect artist, is a most perfect art, there mu be a most perfect artist. Hence, "nature is but the pattern of a art, namely the divine one, intrinsic to things by which these very things are moved to a determinate end."[50]

The conclusion we have just reached points to the reality of a Supreme Architect of the universe. The argument and its conclusion in the general science of nature are brought out here only to meet a difficulty because the scientific proof of the Supreme Designer of the world properly belongs to natural theology. Such proof can be treated in the science of nature only improperly and dialectically. For the science of nature, the conclusion that there is a Supreme Designer of the universe is something provable but not proved.

VII. NATURE AND THE CAUSES

Final causes do exist in nature, and nature can use them when it can find them, as explanatory principles. As modern physics, witnessed by Heisenberg,[51] has made primary matter respectable, so

[49] *Principles of Nature,* ch. 19.
[50] *Commentary on the Physics,* Bk. II, les. 14, n. 268.
[51] Cf. *supra,* p. 45.

recent biologists[52] have reinstated the concept of purpose, though insisting that it does not mean conscious purpose. Of the four causes we have identified, matter and the end are the most important in natural science.

Matter and form are intrinsic causes because they enter into the composition of the thing produced. (Privation is a principle, but not a cause; it is indeed an incidental principle since it vanishes to the extent that the new thing comes to be or to the extent that the new form is acquired.) The agent and the end, external to the thing moved, are extrinsic causes. We would know natural things perfectly only if we knew all four of their causes and knew these causes not merely in general but as resulting precisely in this or that species of thing. The general science of nature pretends to establish only *that* there are four causes for mobile beings. Further investigation belongs to more specialized levels of study.

[52] Cf. for instance, G. Simpson, *This View of Life* (New York, 1964), p. 105.

CHAPTER V
MOTION DEFINED

I. THE RELEVANCE OF DEFINING MOTION

a. Motion is the common predicate of natural science

"Motion consists merely in the fact that bodies are sometimes in one place and sometimes in another, and that they are at intermediate places in intermediate times." This definition of motion as found in Bertrand Russell[1] is an inadequate one. Bodies in motion are never *in* or *at* a place; if so, they would be at rest. Moreover, Russell's definition presupposes that time is better known than motion. Finally, though Russell's intent is to define only local movement, it is desirable to find a definition that applies to all change, taking motion in a wide sense.

Russell's definition is introduced here only to show the difficulty of defining motion. But why is such a definition necessary?

In a causal demonstration, a property is predicated of a subject by means of a principle, and every science is possible only to the extent that there are first principles in that science. *We have already established that a science of mobile being is possible because there are first principles in the physical world* (Chap. II). These principles make demonstration possible. Demonstration, in turn, involves three things: the subject, the middle term, and the property.[2] As was argued in Chapter III, *the subject of the science of nature is whatever comes to be by nature; and the middle terms for demonstrations about that subject are the four causes: matter, form, agent, and end* (Chaps. III–IV).

[1] *Mysticism and Logic* (New York, 1957), p. 80.
[2] *Commentary on the Posterior Analytics,* Bk. I, les. 2, n. 14.

The third item in the demonstrations of our science has not yet been identified. *That item is the fundamental property of mobile being, namely motion itself, and our present chapter, paralleling Book III of Aristotle's* Physics, *is devoted to a consideration of this property.* After an analysis of motion considered in its *intrinsic* character, attention will then turn to *extrinsic* measures of motion, place, and time (Chap. VI).

The reason why motion claims our attention before all other "attributes" in the physical world is that it is the most striking characteristic of sensible things. Motion is involved in the very definition of nature: whoever ignores motion ignores nature itself.[3]

Our study concerns mobile being, and in line with the pedagogical principles developed in Chapter I, our interest in this chapter is motion or change in general. Modern physics speaks of uniform and accelerated motion. But there is need to define motion as such, the genus to which the uniform and accelerated types belong.[4] There is need to achieve a definition of motion in a sense wide enough to include qualitative change, growth, and changes of substance.

b. Two divisions leading to our definition of motion

Following the natural direction of the human intellect, our definition is going to focus upon motion in general rather than upon this or that particular kind of motion. And as division is the way to definition, it will be instructive to approach our definition of motion through a division.

There are two principal divisions of the things we experience. *On the one hand, the things we commonly experience in physical reality can be divided according as they are actual or potential; and on the other hand they can be divided into the ten categories,* namely substance and its nine accidents.[5] By classifying things as actual or potential, we are dividing them as either in a state of fulfillment and realization or in a state of capacity and possibility. Every fertilized seed is potentially an adult plant; actually, however, it is only a seed. Potency thus means mere ability or aptitude; it means possibility. Act is a realization of this possibility.

Divided into the ten categories, a reality is either a substance or one of the nine accidents: the quantified, the qualified, the related,

[3] *Commentary on the Physics,* Bk. III, les. 1, n. 276.

[4] See the division in I. B. Cohen, *The Birth of a New Physics* (New York, 1960), p. 108.

[5] *Physics,* Bk III, ch. 1, 200b, 25–201a, 2; *Commentary on the Physics,* Bk. III, les. 1, n. 280; *Commentary on the Metaphysics,* Bk. XI, les. 9, nn. 2289–2292.

when, where, being situated, being equipped (clothed), to act, and to receive. Motion takes place in several of the categories, as our later discussion will bring out; there is motion according to quantity, as when a thing becomes bigger or smaller; motion according to quality, as when there is a change of color; and motion according to place, as when a thing moves from here to there. In a wider sense, there is motion also in the category of substance, as in substantial change.

The division of realities into the ten categories is not a subdivision of the previous division into act and potency. For act and potency occur in all the categories. What is potentially a substance and what is actually a substance belong in some way to the same category; the potentially red belongs, like the actually red, to the predicament of the qualified. Since act and potency appear in all the categories, the categories cannot be a subdivision of the division of reality according to act and potency. To divide matter according to the categories on the one hand and on the other hand according to act and potency is merely to divide the very same thing according to two different principles of division. Both divisions of reality are necessary in order to understand the definition of motion and the relation of motion to being. Both divisions involve subjects that we already know, since the categories have been studied in logic and since act and potency are, in the science of nature, the same as form and matter.

II. MOTION AND THE TWO DIVISIONS

a. A faulty definition

There is always a temptation to define motion as some kind of passage from potency to act or possibly even as the actualization of the potential. But such apparently easy definitions beg the question.[6] For passage is itself a case of motion; actualization also designates a process of some sort. To define motion as a passage or a process would be simply to say that motion is motion, and such a definition would be a circular one.

In this context let us listen to the definition of motion in Descartes:[7] "motion . . . is the transference of one part of matter or one body from the vicinity of those bodies that are in immediate contact with it, and which we regard as in repose, into the vicinity of others."

[6] *Commentary on the Physics*, Bk. III, les. 2, n. 284.

[7] *Principles of Philosophy*, XXV, transl. E. Haldane and G. Ross (New York, 1955), I, 266.

The use of the term *transference* makes the Cartesian definition beg the question; for like *passage* or *actualization, transference* is a case of what we are trying to define. In the history of thought, there are many examples of definitions of motion which beg the question.

b. Potency and act as "modes"

In approaching our own definition, let us recall from our division that there are two states in which a being may be. It may be *actual,* as the mature oak is actually an oak tree; or it may be *potential,* as an oak tree exists potentially in the acorn. Water vapor in the form of a cloud is *potentially* on the ground; later on, after rainfall, it will be *actually* there. *Potency and act may be regarded for the present as each constituting a status or a "condition" or "mode"*[8] *of being; a being may be in an actual status or in a potential status.* For a being to be in act does not add anything to its content; as Immanuel Kant remarked, there are no more pennies in an actual dollar than in a possible one.[9] Potency and act divide being according to "condition," or "mode," whereas the categories divide being according to content. The possible dollar is in a potential mode; or, more accurately put, my possession of a dollar as yet unearned is potential. When possessed, the dollar will be mine actually and not merely potentially. Considered only in a context of act and potency, a raindrop potentially on the ground and one that is actually there do not differ in their constitution and in the nature of their relation to the ground. But the first is in a mode of capacity and the second has this capacity fulfilled.

c. A third "mode": Imperfect act

In addition to being in act and being in potency, there is a kind of third mode which a being may have.[10] This mode or condition is that of motion. *Motion is a kind of medium between act and potency,* so that a thing in motion is neither in one state nor in another but somehow in between them. A thing that has not yet been moved is in a mode of potency; a thing whose motion is over is in the mode of act; in our third mode, that of motion, a thing is "partly" in potency and "partly" in act. An apple growing red is no longer in mere potency to be red because it has something of red already; but neither is it in full act, because it will become still redder as the

[8] *On the Power of God,* q. 3, a. 8, reply 12.
[9] *Critique of Pure Reason,* transl. N. Kemp Smith (New York, 1930), p. 505.
[10] *On Truth,* q. 8, a. 14.

ripening goes on. In relation to red,[11] such a reddening apple is neither in pure potency nor in full act but somehow in between. A substance being heated is no longer in simple potency to be heated but neither is it actually as hot as it will be when the heating is complete. To be growing red or growing hot is thus somehow to be in the middle ground between being in act and being in potency with respect to the terms of a given motion. This is why motion has been placed among the indeterminates;[12] a thing in motion is neither this nor that — neither fully red nor absolutely non-red, neither hot nor cold. Since motion involves the indeterminate, it is extremely difficult for the human mind to grasp.

From our two examples, that of the apple growing red and of a substance growing hot, motion can be seen at once to be some sort of imperfect act.[13] *What is reddening is in some way red but not perfectly so; what is being heated possesses heat but in an imperfect manner when compared to the term of the process.* Imperfect act is act which involves an order to a further act. If in this imperfect act, e.g., being heated, we consider only the act, we are regarding a given motion to the extent that it is already terminated, whereas if we advert to the imperfection we are considering the motion as unterminated and as having further potency. In the case of local motion, if we consider only what is actual, we are referring to something achieved and ended and no longer potential, whereas if we consider only the trajectory yet to come as opposed to what has already been completed, we are considering a motion according to what is unachieved, unended, and hence imperfect. In contrast to potency, motion is act; in contrast to full act, motion makes reference to unfulfilled potency.[14] Motion is thus an imperfect reality, a mode of being "partly" in act and "partly" in potency.

d. Motion and the categories

With this background, we can now say how motion is related to the categories. What is actually red is clearly in the category of the

[11] "Red" is here being taken as a kind of ideal. A reddening apple may be simply redder than it was before and without a temporal interruption may turn brown. Rest may be only a comparative term, but motion does involve differences, e.g., between the less red and the more red, and these differences have to be explained. This observation should be borne in mind throughout the rest of this chapter.

[12] *Physics,* Bk. III, ch. 2, 201b, 28; *Commentary on the Physics,* Bk. III, les. 3, n. 295; *Commentary on the Metaphysics,* Bk. XI, les. 9, nn. 2302–2304.

[13] *Physics,* Bk. III, ch. 2, 201b, 28; *Commentary on the Physics,* Bk. III, les. 2, n. 285; *On the Power of God,* q. 8, a. 1, reply 9; *Commentary on the Metaphysics,* Bk. XI, les. 9, n. 2305.

[14] *Commentary on the Physics,* Bk. III, les. 2, n. 285.

qualified; and what is actually large belongs to the category of the quantified. Now what is growing red or growing large is reducible to the category toward which it tends, as the imperfect is reducible to the perfect. A baby is called a man, even though it is not yet in all respects a man; a reddening is reducible to the category of the qualified and growth to the quantified in similar fashions.[15] Wherever motion does occur, it is said to be reducible to that category in which it is taking place as an imperfect reality is reducible to the perfect.[16]

It is clear at any rate that motion is not something only in act or something only in potency. What is in act has already been moved and what is in potency has not yet been moved at all.

III. THE FIRST DEFINITION OF MOTION

a. Motion as act

Motion is *the act of what exists in potency precisely insofar as it exists in potency.*[17] In Aristotle's words, "The fulfillment of what exists potentially in so far as it exists potentially, is motion."[18] But like all definitions that are not merely arbitrary and artificial, our definition of motion must be explained and defended. It claims to represent what men think about when they refer to motion, i.e., what they mean when they use the term or some synonym corresponding to it. Our definition claims that motion is the act of the potential as potential or the fulfillment of a capacity precisely as capacity. The three parts of the definition must be exemplified and explained: motion is *act;* it is the act *of the potential;* it is the act of the potential *as potential.*

What is undergoing motion was previously in a state of potency but, since it is in motion, is no longer in that previous state; it is therefore in the state of act or, put more simply, it is an act. An apple that is growing red is no longer merely in potency to be red, and a leaf that is falling earthward is no longer in the same previous state of sheer potency to be on the ground. What was in potency but is no longer so must somehow be in the condition of act.

What was previously in a potential condition within our mobile world had a potency to two acts:[19]

The first is a perfect act, as when our apple is as red as it will be or when the leaf is actually on the ground. In the case of a house, there

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15 See note 11.

16 *Commentary on the Physics,* Bk. III, les. 1, n. 282; les. 5, n. 324.

17 *Commentary on the Physics,* Bk. III, les. 2, n. 285; *Commentary on the Metaphysics,* Bk. XI, les. 9, n. 2294.

18 *Physics,* Bk. III, ch. 1, 201a, 10–12.

19 *Commentary on the Physics,* Bk. III, les. 2, n. 287.

is a potency in the material for the house to be completely made into a house. The example of building a house, which will be frequently used throughout this chapter, involves not one motion but many. To consider it as a single motion is to invoke a model that is dialectical only. It is not intended to reproduce reality, any more than the example of statue-making in the case of matter and form; it is intended to help us find reality by suggesting inductions concerning the physical world. Finally, house-building has been chosen as our dialectical construct because it involves the world we know well enough to dominate — the world of art.

There is also another kind of act to which things are in potency and which the kind of act just mentioned really presupposes: this is an imperfect act which is motion; and in this status we find such things as the reddening apple, the falling leaf, the house under construction, the water being heated. Here the things undergoing change are not yet in perfect act because in perfect act there is a term to motion; where there is perfect act, motion is complete. But our reddening apple, our falling leaf, our water being boiled, and our house a-building are not in perfect act. The state they are in, as opposed to perfect act, is imperfect act. This is motion.

Corresponding to the distinction between perfect act and imperfect act is a twofold potency: a potency to become and a potency to be. An apple that is green has a potency to become red and also a potency to be red. Materials have a potency to become a house and also a potency to be a house. The act of the first potency in both of these examples is motion; the act of the second potency is the term of motion.

Whether the distinction between perfect and imperfect act and the distinction between the two corresponding potencies be admitted or not, this much is clear: Motion is in some way act since what is in motion is no longer merely potential.

b. *Motion is the potential*

Motion is the act *of the potential. Only what is in potency can be characterized by motion. To the extent that a potency in the physical world is fulfilled the corresponding motion is over.* Thus, the materials in a house already built cannot undergo the motion involved in the building of that house; they may, and obviously do, have potencies to other things besides this house, but precisely as the materials of this house that is already built, their potencies are fulfilled with the completion of the house itself. In a kindred way, the apple that is as red as it will be has no more potencies to become this color which it already possesses; and motion toward such a color becomes impossible. Only what has potency can be moved, and when this potency is fulfilled, there is no more motion that fulfills it.

c. *Motion is of the potential as such*

The most difficult phase of our definition comes with the addition of *as potential.* Motion is the act of the potential *precisely as potential.* This is often put: Motion is the act of the potential *qua* potential. To identify motion simply as an act and even to characterize it as the act of the potential without adding the last phrase is to speak of motion as already complete and hence to refer to the term of the motion rather than the motion itself. In the case of a house, the act of the buildable, i.e., the act of the potential, is not the process of being built but the term of the process; the act of the buildable is the built house, not its process of construction. Hence, our definition in its third part refers to the fact that the motion being defined is not at its term and is not complete but is more or less distant from its term, therefore still under way.[20] Why does this third part of our definition mean that the motion is still going on?

In another dialectical model, which once again is only a model because it involves many motions, bronze is in potency and also in act but not in the same way. It is actually bronze; it is potentially a statue. Now the motion that the bronze undergoes when being shaped into a statue is the act of the bronze, not insofar as it is bronze — for such an act is the reality of bronze itself and not a statue — but insofar as it has a potency to something else, the figure given it by the sculptor. If we said in our present context that motion is the act of the potential we would be designating the bronze; but when we add that the motion under consideration is the act of the potential *insofar as there is a potency* (to something else), we are signifying that motion is going on and that the term or perfect act of the process has not yet been achieved. It is not the same thing to say *bronze* on the one hand and on the other *potency to be a statue.*[21] They are different in a significant way. The making of a statue is not the act of the bronze for such an act makes bronze what it is as bronze — but the making of a statue is the act of a potency that, unlike the bronze, is not yet in act (the

[20] *Summa contra Gentiles,* Bk. III, ch. 23; *On Truth,* q. 5, a. 5; *Commentary on the Metaphysics,* Bk. XI, les. 9, nn. 2296–2297.

[21] *Physics,* Bk. III, ch. 2, 201a, 30–33; *Commentary on the Physics,* Bk. III, les. 2, n. 289.

statue). The motion, i.e., the becoming of a statue, is the act of the bronze not insofar as it is bronze — for as bronze it is already made or moved to be bronze — but insofar as it is in potency to be a statue. The act of the potential taken alone without our third phrase could be either bronze or the completed statue, either the state previous to motion or the state after it, depending on our viewpoint. *The act of the potential only insofar as it is still in potency to be a statue is the motion we are trying to characterize.*

The act of the potential precisely as potential is motion. This is our definition and it correctly expresses what we mean when we think or use the term *motion*. Previous to the act that is motion there is only potency to that act; after this potency is fulfilled there is only the act which terminates the motion: the act that is motion is over, completed. A thing in motion, therefore, is moved neither before nor after it is the act of the potential precisely as potential.

Thus, although our language finds it awkward to get many words like *buildable* as contrasted with *built*, the heating of water is the act of the *heatable qua heatable;* the bleaching of wood is the act of the *bleachable qua bleachable*. The growth of a cat is the act of the *enlargeable qua enlargeable.*

A thing in motion is always other than it was, and the third part of our definition brings out this fact. A thing that has changed is also other than it was, but the change is over and this is not the otherness connected with motion. There is otherness as in the case of a man who has moved from one place to another; at the end of his motion, he is other than he was. But this is not otherness as expressing motion itself. Rather it is otherness at the *end* of a motion by comparison to a motion before it *began*. At neither end is there motion.

As the act of the potential *qua* potential, motion is the *act of the potency for otherness*. As act, it is more than just the previous state where only a potency for otherness existed; as potency, motion is less than the final state where the otherness has been achieved. Motion is the act of something only insofar as it has a potency for otherness, and so our definition expresses the fact that a thing in motion is neither simply potentially other nor actually other but is *being made other* by the fact that its potency for otherness is being actualized. Because of this tendency to otherness, motion seems to be a special kind of relation.[22] But this point need not be further examined in an introductory book.

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[22] *Commentary on the Physics,* Bk. III, les. 1, n. 280.

Motion is the most imperfect kind of act. It is fitting that such an act should be the instrument for all our natural knowledge. The most imperfect kind of act forms an object proportioned to the most imperfect level of intelligence, that of man.

IV. THE SECOND DEFINITION OF MOTION

a. Our first demonstration

After the definition of motion, the inquiry can turn to the subject of motion. Is motion in the agent or in the thing moved by the agent, or is it in some way in both? The answer to this kind of question will enable us to identify mobile being more precisely, for it will enable us to know the subject in which motion takes place.[23] Our search to answer our question will bring us to the first perfect (*propter quid*) demonstration in the general science of nature. This demonstrative syllogism should be stated right away:

The act of the potential precisely as potential is the act of the mobile precisely as mobile.
But motion is the act of the potential precisely as potential.
Therefore, motion is the act of the mobile precisely as mobile.

In order to penetrate this argument, it is first of all necessary to understand what is being said. Our conclusion actually contains another definition of motion.[24] It shows what the subject of motion is. It states that motion is in the mobile, i.e., in the thing capable of being moved. The mobile is here being contrasted with the mover or agent.

The distinction between the mover or agent on the one hand and the thing capable of being moved by that agent on the other will be a crucial one in the following discussion.

b. Objection: Motion is in the mover

Yet contrary to our conclusion there are initial indications that motion goes on in the mover or agent as well as in the thing capable of being moved by that agent. *For one thing, every natural mover is in a state of potency to be a mover, and in this respect, it must be moved to perform as an agent by another agent outside itself.* The hammer as a mover will drive a nail only when the hammer is moved by the hand of the carpenter; it would therefore look as though motion is not only in what receives the motion, i.e., in the nail, but also in what communicates the motion, i.e., in the hammer. Moreover, since natural motion occurs by contact between the mover and thing moved and

[23] *Disputed Question: The Soul,* transl. J. Rowan (St. Louis, 1949), a. 1, reply 15.
[24] *Commentary on the Physics,* Bk. III, les. 4, n. 297.

since the thing moved always reacts in some way upon the mover, it would look again as though the mover itself undergoes motion. The saw that cuts wood is dulled by the cutting, and even though it is a mover, it would thus seem to be moved or changed.

Unless both of these difficulties can be resolved, there is no need of trying to show that motion, as such, is not in the mover but in the mobile, i.e., in the thing capable of being moved.

c. *Motion is in the mobile*

Concerning our first objection, it can be argued that to the extent that a mover, i.e., the hammer, is moved by something else, e.g., the hand, the mover is not precisely a mover but a being that is moved; therefore it can still be true that as a mover the hammer is not properly said to be moved.[25] *Concerning the second objection, that the thing acted upon reacts upon the agent, it can be proposed that precisely as acted upon rather than as acting, the "agent," e.g., the saw that is dulled, is not truly an agent but a "receiver."*[26] The two objections, then, do not destroy the truth of the conclusion that motion is the act not of the mover but of the mobile, i.e., the thing capable of being moved.

The truth of this conclusion follows at once from the truth of the premises in our demonstration. Since the minor has already been established in connection with our first definition of motion, it remains now only to establish the truth of the major proposition, i.e., the act of the potential as potential is the act of the mobile as mobile. *The proof of the major is that such an act, i.e., the act of the potential as potential, cannot be the act of the mover for the reason that the causing of motion must be the act of something actual, not the act of something potential.*[27] The potential as such cannot operate; a potential storm can never cause any damage or do any good. It simply cannot operate as a cause. Only what is actual can cause. As actual, then, the agent does not undergo the act of the potential as potential — although as moved by some other cause, as a receiver rather than an agent, the "agent" may be potential. The only other possible subject of motion is the mobile. As the act of what exists in potency, motion takes place only in the mobile; motion is in mobile being, and what goes on in the producer of the motion cannot properly be said to be motion.

How then shall we characterize the act of the mover?

[25] *Ibid.*, Bk. III, les. 4, n. 301.
[26] *Ibid.*, Bk. III, les. 302.
[27] *Ibid.*, Bk. III, les. 4, n. 302; *Summa contra Gentiles*, Bk. III, chs. 23, 69.

V. ACTION AND PASSION

a. One motion: Two relations

There is no causing unless something is being effected. Analysis of experience will show that it is the same motion which in different ways characterizes both the agent and the receiver.[28] Thus the impressing of a seal on wax is not two motions, one in the seal and the other in the wax. Rather it is one motion impressed *by* the seal *on* the wax.[29] The seal is impressing something on the wax to the precise extent that the wax is receiving the impression; and the wax is receiving the impression just to the extent that the impression is coming from (or rather is being made by) the seal. Thus there are not two motions here but only one; it is *by* the seal but *on* or *in* the wax. In generalizing the principle in question, it may be said that motion is *by* the mover as *by* an agent cause;[30] but it is *in* the mobile as *in* a receiver or material cause or "patient."

It is important here to tighten up our terminology even more. The agent is the principle from which or by which (*terminus a quo*) motion originates, and motion considered in reference to the principle from which it comes is called action. However, it is extremely important to distinguish between the "principle from which" (*terminus a quo*) of motion and the "principle out of which" (*terminus ex quo*). The *principle out of which* (*terminus ex quo*) motion comes is the patient, not the agent. Motion really comes out of the patient. Nothing ever goes out of the agent into the patient. Motion rather comes forth from the patient under the causality of the agent. Motion in this light is *out of* the patient and *by* the agent. As the mover, the agent remains extrinsic to motion. The patient, or receiver, is the material cause *out of which* motion originates and *in which* motion remains. In summary, the patient is that *out of which* (*terminus ex quo*) and *in which* (*terminus in quo*) motion occurs, while the agent is that *by which* (*terminus a quo*) motion takes place. Action and passion, like the impressing by the seal and the impressing on the

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[28] *Physics*, Bk. III, ch. 3, 202a, 18–20; *Commentary on the Physics*, Bk. III, les. 5, n. 314.

[29] Cf. J. McWilliams, "Action Does Not Change the Agent," in *Philosophical Studies in Honor of the Very Rev. Ignatius Smith*, ed. J. Ryan (Westminster, 1952), pp. 208–221.

[30] *Commentary on the Physics*, Bk. III, les. 4, nn. 306–307; les. 5 (*passim*); *Exposition of the Posterior Analytics*, Bk. II, les. 10, n. 105.

wax, are not two motions but one. As by the agent it is action, and as in or from or out of the patient it is passion.[31]

In terms of our first definition, motion is defined as the act of both the agent and the patient but as the act of each in a different way.[32] The difference between motion as characteristic of agent on the one hand and of the patient on the other is stated in the second definition. That is why the second definition reveals that the reality in which motion takes place, i.e., the subject of motion, is the mobile, the thing capable of being moved. While characteristic of the mover also, motion is *by* it. It is *in* and really *out of* (*terminus ex quo*) the mobile. Imperfect act, like perfect act, is an emergent from the material cause, because nothing really passes to or into the patient from the agent.

A thing can be one in several ways: First there is oneness in both being and relation,[33] and an example of this would be shoes and leather foot-coverings which are truly identical with each other. A second way of being one is according to being, but not according to relation, as the motion of the agent in relation to the motion of the receiver. Motion is here truly one in being but different in relation. It is by the agent; it is in the patient. Motion is *in* the receiver as an effect.

b. Motion is by the agent and in the patient

There are many examples to show where things may be one in being but twofold in their relations. Buying and selling, for instance, are one transaction; nothing is bought unless something is sold and vice versa. The item exchanged is the very same thing for both parties. But to the extent that there has been a transaction *accomplished* at all the item is delivered by the seller and to the buyer.

A similar instance is teaching and learning. The same knowledge is involved at both ends of the process; it is, however, *by* the teacher but *in* and *out of* (the very meaning of *education* is an *educing*, a leading out of) the learner. In a fashion similar to motion, the ascent and descent of a mountain road are the same stretch of space. But there are different relations at each end of the trajectory as our language — "up" and "down" — reminds us.

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[31] *Commentary on the Metaphysics,* Bk. XI, les. 9, nn. 2312–2313; *Summa contra Gentiles,* Bk. III, ch. 16.

The word passion here is to be taken in its older and etymological sense of "receiving" something, from the Latin *pati,* meaning to suffer. Our English word "patient" has a similar derivation and in this book is taken to mean receiver.

[32] *Commentary on the Physics,* Bk. III, les. 5, n. 322; *Commentary on the Ethics,* Bk. IX, les. 7, n. 1846.

[33] *Commentary on the Physics,* Bk. III, les. 5, n. 318.

It is interesting to consider the implications of action and passion in a series of causes where one thing moves another until some final effect is produced. Motion, in the end, is not like an item passed by a seller to a buyer. Let us consider the case where our hand moves a hammer and the hammer drives a nail. For this process to go on, other causes will be operating and other effects will be produced. But in order to simplify our consideration, let us consider only these three processes, that of the hammer, that of the hand, and that of the nail. In such an isolated series of causes, the hammer is a moved mover; as moved, it has its own potencies reduced to act, and as a mover, it is the instrument by which there is a similar emergence in the potencies of the nail. But it is surely not the same something, as in buying and selling, that is received from a cause by a moved mover and communicated by such a mover to the effect. Motion in the hand, the hammer, and the nail is not something like a baseball passed from one player to another; it is not like a package which is now here and now there as it proceeds from a counter to a shipping department and finally to the address where it is delivered. In reference to our example, according as motion *by* the hand is motion brought forth *out of* the hammer, the hammer is a receiver or patient; but according as the hammer in turn acts upon the nail, the hammer is an agent. The hand actuates the passive potencies of the hammer whose active potencies, as a cause, then actuate the passive potencies of the nail.[34] But the motion is not mechanically passed along. The hammer contributes something original in the process; it does not merely relay to the nail the motion received from the hand; if that were so, the bare hand could drive the nail as well as the hand assisted by the hammer. Something happens in between the causal motion of the hand and the effected motion in the nail. This original something comes from the very natural substances out of which the hammer is made; for, as we said earlier, natures when acted upon do not react in a merely formless and purely passive way. They contribute something of their own to the effect.

Motion is one. As by (a quo) the agent, it is action; as in or out of (ex quo) the recipient, it is passion. But this insistence on the unity of motion in the cause and the effect does not affirm an absolute unity between action and passion. They are the same motion with differing relations. Action and passion are each motion but motion as

[34] Active potency is the power to *do* something *to* something, and passive potency, the power to *receive* something *from* something; cf. e.g., *On the Power of God,* q. 1, a. 1.

relating to its active cause on the one hand and to its receiving subject on the other.[35]

To discuss motion as such abstracts from whether we are discussing action or passion. It is only when something else is added to the concept of motion that action and passion are seen to be different. When this something else that is added to motion is the relation of the agent to motion, we are considering action; and when this something else that is added to motion is the relation of the recipient to motion, we are considering passion.

c. *Motion and the categories*

Motion is related to the categories in a twofold way.[36] To the categories in which it takes place, e.g., substance, the quantified, the qualified, where motion is reducible as the imperfect is reducible to the perfect. This point has already been seen. In the second place, motion is related to the categories of *to act* and *to receive.* To act is to move as by the agent; to receive is to be moved as in the subject or patient.[37]

VI. MOTION AND THE SUBJECT OF OUR SCIENCE

a. *Motion and our intellect*

Our first definition of motion has enabled us to reach a demonstrated conclusion concerning the proper subject of motion. *It is with motion as in the mobile being, i.e., with the most imperfect of all acts, that the human intellect, the most imperfect of all intelligences, begins its quest for truth.* From such an imperfect act, everything else, including the act of the agent, is known. Anything less than such an imperfect act would be merely potential and hence unknowable; anything more would plunge us into a knowledge whose presupposition we had not duly examined. Motion as such is knowable to us only because of the element of act which it contains and which our original definition records in its very first part.

Knowledge is possible to the extent that there is in the mind a certain kind of unification or organization. But potency as such is disunified, plural, indeterminate, at any rate unorganized. This may be shown by simply observing that what is in potency can be actualized

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[35] *Physics,* Bk. III, ch. 3, 202b, 19–25; *Commentary on the Physics;* Bk. III, les. 5, n. 322; *Commentary on the Metaphysics,* Bk. XI, les. 9, nn. 2309–2313.

[36] *Commentary on the Physics,* Bk. III, les. 5, n. 324; *On the Power of God,* q. 3, a. 3, reply 8.

[37] *Commentary on the Physics,* Bk. III, les. 5, n. 325.

in a *number* of ways (i.e., is plural) depending on the character of the agent acting upon it;[38] snow that is in potency to be melted can be dissolved in a number of ways depending on the heat that is applied and on the points of application. Potency says plurality or indetermination; and because knowledge requires unity or determination, potency resists our efforts to know it. When in act, a thing is definitely and determinately this or that; it is in terms of act that things are knowable to us.

b. Motion: Demonstration and observation

Motion, it was remarked, should be classed in some way among the indeterminates; a thing in motion is neither this nor that. Yet whatever is in motion does have a minimal amount of act or determination. It is at one remove from the potential; and it is this imperfect act which makes mobile being — and everything else in the whole reach of our intelligence — intelligible.

We have seen a connection now between the definition of motion and the subject of our science. As a property of a subject and as demonstrated of its proper subject by a middle term, motion has been shown to exist in the mobile because motion is the act of the potential or subjective precisely as potential or subjective. Such is the first demonstration in our science of nature. It reveals to us that motion, observed by induction to be going on in mobile being, must necessarily exist in such mobile being rather than in the mover. *Our demonstration has therefore shown us the proper cause or reason why motion must (de jure) exist in that subject where it is (de facto) observed to exist.*

c. Terminology

In order to make our first definition of motion and to demonstrate our second, an application has been made of our first principles of nature, namely matter and form. In our sense of the terms, matter is another way of saying the potential, and form is another way of saying act. Matter is the only kind of passive potency that can be found in the physical world by our science of nature; and form is the only kind of act that this science can grasp. In metaphysics, another kind of act and another kind of potency are discovered to exist;[39] but

[38] *On Truth*, q. 8, a. 10.

[39] The reference here is to essence and the act of existing, which are related as potency and act. But the philosopher of nature has no right to assert this distinction in the things of nature. Matter and form must account for our world until the need for non-physical principles is established by the demonstration of the existence on a non-physical world. (Cf. pp. 161–162).

throughout the remainder of this work, matter and potency can be considered as synonyms and so also can form and act.

In the mobile world, action is what characterizes a mover, and passion, the thing moved. In order to avoid misunderstandings that frequently occur in the minds of beginners, it may be appropriate to remark that not every action involves motion.[40] The activities of the human intellect and will, for instance, and even the operations of our senses and our sense appetites are cases of action or operation: but in the proper sense of the word, they cannot be called motion. According to our analysis so far, motion always involves a privation or loss of some kind. In a thing moved, the old form is lost to the extent that a new one is acquired. But for their proper operations human knowledge and will do not involve privation.[41] No old knowledge is lost when new knowledge is acquired; indeed, the old knowledge is not only retained but strengthened. In a similar fashion, acts of virtue do not entail privation or loss but on the contrary are a gain in strengthening what already exists. Acts of thinking and willing are perfect acts.[42] Motion is an imperfect one.

Our definition of motion and our discussion of action and passion are useful to the remaining parts of our science of nature. If everything in the universe involves motion, it is proper that motion in general should be defined. Generic knowledge is naturally acquired before specifics are known.

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[40] Creation, for instance, cannot be a motion because it does not come from any pre-existing subject. *Summa Theologiae,* I, q. 42, a. 2, reply 2; *Summa contra Gentiles,* Bk. II, ch. 17.

[41] *On Truth,* q. 24, a. 10, reply 2.

[42] *On Truth,* q. 28, a. 9, reply 11; q. 24, a. 1, reply 14; q. 8, a. 14, reply 3.

CHAPTER VI
PLACE AND TIME

I. EVIDENCE THAT THERE IS PLACE

a. Relevance of the problem

Motion has thus far been considered in its intrinsic character and defined by its intrinsic causes, potency (matter) and act (form). Our search now turns to the extrinsic, to the measures of motion, namely place and time.[1]

But why do we have to probe into the problem of place?

First of all, everything that exists in the mobile world exists somewhere, and what does not exist anywhere is not thought to have physical or material existence.[2] Now if it pertains to the science of nature to probe mobile being and its fundamental or most general characteristics without which it would not be regarded as physical, then it is surely proper to ask in our present context what it is to have a *where* or to be in place.

As a second argument which makes it appropriate to discuss place, it should be observed that the most common form of motion in the universe is local motion, i.e., change of place, and *it would be illogical to attempt a discussion of local motion without having first determined what is meant by location and by place.*[3]

b. Evidence for place

What is the evidence that place exists in the physical world? Our argument is that just as there has to be a matrix or substratum called mat-

[1] We have passed over the problem of motion and the infinite treated by Aristotle in his *Physics,* Bk. III, chs. 4–8.

[2] *Physics,* Bk. IV, ch. 1, 208a, 30; *Commentary on the Physics,* Bk. III, les. 1, n. 277; Bk. IV, les. 1, n. 407.

[3] *Physics,* Bk. IV, ch. 1, 208a, 32; *Commentary on the Physics,* Bk. III, les. 1, n. 408.

ter in which two forms succeed one another, so it is necessary to hold that there is place in the world because there must be a *where* in which bodies in local motion succeed one another.[4] Moreover, place is not only a reality but it is also something distinct from the bodies that are in it. For if the place of a body were not distinct from that body, then a body undergoing local motion would take its place along with it and would have the same place after the motion as before.[5] *Bodies that occupy the same place after local motion as before could not be said to undergo local motion or change of place. In other words, if place is not truly distinct from bodies that are in it, change of place becomes a contradiction.*

From a more positive viewpoint, local motion requires that the old place occupied by a body remain constant and unchanged when the body moves out of it and that the new place likewise remain constant and unchanged as the body moves into it.

At first sight, place seems to be some kind of receptacle in which bodies succeed one another and which itself remains (at least relatively) fixed throughout the change. In a pedestrian example, place may even be likened to a vessel which can be emptied of one thing and filled by another and which, in the process, remains distinct from the two bodies it successively contains.[6] It is meaningful to ask, in a set of circumstances, *where* the water is and meaningful to get an answer like: "It is in the glass." It is therefore meaningful to ask the more general question of what we mean by *where*.

This example of water in a glass is just a starting point, taken as a dialectical model from the world we know well enough to dominate, namely human art. From such an example, place would seem not only to exist but also to be distinct from bodies that are in it. Does such a containing place exist, not just in the human world of glasses and other receptacles, but also in nature? Our initial response must be positive because in the things of nature the mind also finds that the *where*-question has meaning.

c. A reason for local order

Our universe is locally ordered at least in some overall way. Why is the atmosphere above us rather than below and the lithosphere below us rather than above? If the *where* of the air and of solid bodies were

[4] *Physics*, Bk. IV, ch. 1, 208b, 1–3; *Commentary on the Physics*, Bk. IV, les. 1, n. 411.

[5] *On Truth*, q. 1, a. 6.

[6] *Commentary on the Physics*, Bk. IV, les. 1, n. 411.

interchanged, or more radically, if solid bodies were dispersed like the atmosphere, life, certainly human life, would not be possible on whatever we would then call the earth. *There is a local order among the things in our world, and this has to be explained. Unless the disordered character of chance is invoked, such an order requires that there be final causes at the level of place.*[7] All physical things have *wheres* according to their natures.

To approach this question from another angle, it may be argued that man requires a definable set of natural surroundings in order to exist, e.g., oxygen, heat, food, a solid underpinning like the earth, etc., and when he goes off into space, he can do so only by taking similar but artificially made surroundings along with him. Fish belong in water of different kinds and different depths or pressures. Animals at home on some parts of our earth would perish elsewhere. Such living things tend to seek their natural habitats if they stray from them and to remain there when they are in them. In more familiar biological terms, all living things have environments proper to their kind, and in accordance with the analyses of Chapter IV, such tendencies of organisms to suitable surroundings have to be explained by final causality (or by the absurdity of chance). For there is order in such natural processes as adaptation, and order requires end or goal. Though man may not be able to name in any detail the environments proper to non-living things, is it not necessary to recognize, from the fact of the general local order in our world, that even the different kinds of non-living things have places natural to them, in a fashion distantly analogous to the natural place of a fish which is water and the natural home of a polar bear which is the cold regions of the earth? For even in the locations of non-living things there is order, and order requires final causality. Would the air around the earth fulfill its nature if it surrounded the moon instead, and in such a transposition, what would happen to life on earth?

Gravitation by itself cannot completely account for this local order on earth (which may be considered here as a sample of cosmic order in general). As the order in all natural processes afforded evidence for final causality in general, so the local order that we experience, the arrangement of heavy and light bodies near our earth, would argue that different kinds of bodies have places natural to them, that they are attracted to these places when out of them, and that they tend to remain there when in them. The presence of gravitation, to

[7] *Ibid.*, n. 412.

use the suggestion of Copernicus, may account for the material or even agent cause of this attraction between bodies;[8] but it does not dispense with the fact of final causality as the basic reason for the local order in the universe. In the light of what has previously been said, gravitation may explain the production of effects, but it does not explain why the processes in question are ordered ones. *Place would seem to function in nature as a final cause.*

II. PRELIMINARIES TO A DEFINITION OF PLACE

a. Summary of evidence for place

Despite all of the difficulties concerning the nature of place based on gravitation and other theories of modern science, the facts alleged to show the existence of place cannot be denied. There remains the evidence that a thing which does not exist somewhere is not thought to have physical existence. There is the even stronger evidence that in any local motion something distinct from the thing moved must remain constant and unchanging. This is place. In working toward a precise definition of place, a fourfold division of propositions regarding place is in order.[9]

b. Preliminary steps to definition

1. The answer to the question: *where?* always states the environment in which a body is. Place is therefore regarded as surrounding that which is in place, and as local motion plainly shows, this surrounding environment must be distinct from the located body.

2. The primary place of a thing must be physically equal to the thing located in that place. For example, consider the milk in a bottle; the place that actually surrounds the milk is neither larger nor smaller than the volume of the milk itself. It is physically equal to that volume.

3. Everything that is located must have a place simply because everything that has physical existence must exist some*where.*

4. Finally, though it is necessary to abandon the view shared by Aristotle and Newton that there is any such reality as an absolutely fixed reference in our universe, there is convincing evidence *that* there is some kind of natural place for each different kind of body. For

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[8] *On the Revolution of the Heavenly Spheres,* in *Great Books of the Western World,* XXVI, 521.

[9] *Physics,* Bk. IV, ch. 4, 210b, 33–211a, 4; *Commentary on the Physics,* Bk. IV, les. 5, n. 446.

there is a local order in the world and efficient causes alone are not enough to explain order. It is a matter of common observation and experience that, unless there is interference, heavier bodies arrange themselves differently from light ones. There must be a reason for this natural local order and that reason, as the reason for any order, must be one of final causality, in which locally moving bodies seek to fulfill their natures as parts of an ordered world. Otherwise, we have to say that the order in our world is one of coincidence. Agent causes only execute cosmic order but do not by themselves account for the order that they are executing. Such an order requires recognition of natural places for different kinds of things.

III. DEFINITION OF PLACE

a. The definition explained

With these preliminaries behind, the definition of place may now be approached. If it is to be a good nominal definition, it should first of all formulate what men think about when they speak of place and of local motion; second, it should solve the difficulties raised by those who deny the existence of place; third, it ought to enable us to understand the properties observed concerning place.

Accordingly, place may be defined as *the innermost immobile surface of a surrounding body.*[10] The example of water in a glass may be a good dialectical starting point to clarify the various parts of this nominal definition.

1. Place is a *surface.* When water is in a glass, it does not compenetrate the glass. The material of the glass, rather than the water, occupies the region within the walls of the glass. To say that water is in the glass means that the water is contained by the inside *surface.*

2. The preceding sentence has made a transition to another aspect of our definition. Water is contained by the *innermost* surface of the glass as opposed to the outside surface that would be grasped by the hand in the act of drinking. Place is the innermost surface of a container or, as it is sometimes put, it is the *first* surface. The significance of this word is that the place of a thing is the first surface outside of the located body.

3. Place is *immobile,* at least in a relative sense. Our previous discussion of place forced us to the conclusion that local motion is pos-

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[10] *Physics,* Bk. IV, ch. 5, 212a, 20–21.

sible only if something at each end of the motion remains immobile and unchanged. This immobile term is *place.* If the place of a locally moving body were carried along with it, there could be no local motion at all because a body at the end of such a motion would have the same place as before.

But there is a difficulty in this context. Suppose that a ship is anchored in a river with water continually flowing by it. It would appear, in these circumstances, as though the surface of the water surrounding a ship is something mobile and that in certain cases at least, if not in all, there is no such thing as an immobile surface.

In responding to this difficulty, it should be said that although the parts of the stream that touch the ship are materially mobile, i.e., there is a different matter or content touching the ship from one moment to the next, nevertheless the same order or form remains when new water replaces the old. Water thus changes in a material way but not in its character as place. It is this order or form (not the content) of a surrounding body which constitutes the place of something else. If the ship happened to be standing in drydock, the water flowing around it might be removed, and air would then become the surrounding body. But the order or form of the air around the ship would then constitute the place of the ship. In other words, place involves only formal immobility, not material immobility.[11] Unless we are willing to admit such immobility on the part of place, it is necessary to allow that in local motion the place of a thing changes along with it.

4. Place is the surface of a surrounding *body*. The surface surrounding a thing that is in place must be the surface of a body and not a purely geometrical surface. For a purely geometrical surface would not exist separately in physical reality; and as a geometrical surface only, it would make place something mathematical rather than physical in character. As surrounding a body, place is an *adjacent* or *contiguous* surface. It *cannot be continuous* with the body that is in it; for otherwise, it would be a part of the body in place and not something distinct. It is outside the thing that is in place as the first surface of a surrounding or containing body.[12]

In this connection too it might be pointed out that the movement of the various parts within a thing that is substantially one, e.g., the movement of the molecules in a living organism, is not a movement

[11] *Physics,* Bk. IV, ch. 4, 212a, 15–18; *Commentary on the Physics,* Bk. IV, les. 6, n. 468.

[12] *Commentary on the Physics,* Bk. IV, les. 6, n. 466.

in place. Such movements are in the order of posture or *situs*. A thing possessing such movements would be said to be undergoing local motion but only in some accidental way. Thus a sleeping dog could be said to be essentially at rest but accidentally and by reason of its parts to be in motion.

b. Answer to difficulties

Difficulties against admitting the reality of place can now be confronted. One such objection might be that if place is something real, then, when a thing is in place, there are two bodies — the place and the located body — in the same "place."

In reply to this objection, our definition of place has emphasized that place is a surrounding surface. It is not coterminous with the body that is in place. It does not overlap such a body. It surrounds it as something contiguous and adjacent. Hence, although place is of a body, i.e., the surrounding body's surface, place is not a body, and location does not require that there be two bodies in the same place.[13]

A second difficulty might be that since quantity, mathematically considered, does not involve place (because the position of any mathematical entity like a point is identical with such an entity), therefore place in physical reality does not exist as something distinct from things that are in place.

But this objection does not take account of the difference between the mathematical and physical orders. Place must be distinct from the thing that is in it, as local motion shows. Place must in fact be outside the located body in order to be separable from that body in local motion. Unlike a mathematical body terminated by its own outer surface, physical bodies always have surfaces of other bodies adjacent to them and surrounding them.[14] Position is in the essence of a geometrical entity; but it is something outside the essence of a physical entity and is determined by what surrounds the physical entity in question.

A third and more formidable difficulty is that mechanical forces, exerted on objects in space, can account for cosmic order, without an appeal to place. In order to face the problem, it is necessary to distinguish between space and place.

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[13] *Summa Theologiae,* I, q. 8, a. 2.

[14] Except the bodies on the outer (and perhaps expanding) frontier of the universe which involve place by reason of their parts but are not related to place in a primary manner. *Physics,* Bk. IV, ch. 5, 212b, 12–15; *Commentary on the Physics,* Bk. IV, les. 7, nn. 476–480.

IV. SPACE: A MATHEMATICAL ENTITY

a. Definition of space

The space of a body is its internal extension. The space of the world is the sum of the extensions of all bodies in the world.[15]

To justify these claims, it may be argued that the accidents of a material substance come to it in a certain order.[16] First there is quantity, which spreads out the substance and without which accidents like color would be unextended and hence insensible. After quantity, in the ontological makeup of a sensible object, there are the qualities such as color, hardness, etc. Now the mind may abstract substance and quantity, the first two members of the triad above, and consider this, apparently the purely quantified, as a receptable for the complete physical reality of substance plus quantity plus the sensible qualities. In so doing it considers substance and quantity in a twofold way, inserting a separation into things which is not there in reality: It takes the quantified substance, apparently the purely quantified, first as a receptacle and then takes the quantified substance (this time along with the qualities) as a thing received. *That so-called pure and mentally separated quantified being, taken as a receptacle, is what we ordinarily call space.* It is only mentally separated from the thing or things taken to be in it. Space is thus a mathematical entity. It is the mathematical reality of a body abstracted by the mind and then conceived as a receptacle for that body. And the space of the universe is the sum of such small-scale spaces.

In summary, the separation between space and what is in space is not real but mental. We *consider* the mathematically quantified to be a receptacle for the sensibly qualified, and the former is named space.

b. Space as mathematical

Because of its quantified, rather than mobile character, space is a mathematical, rather than a physical, entity,[17] and it can be considered only to the extent that we are interested in the mathematical

[15] This seems to be Newton's notion: cf. *The Mathematical Principles of Natural Philosophy*, transl. A. Motte, rev. F. Cajori (Berkeley, 1947), p. 6.

[16] If space is nothing apart from the dimensions of bodies, it is no wonder that F. H. Bradley cannot find it: "It is lengths of lengths of nothing we can find," *Appearance and Reality*, p. 37.

[17] The problem of whether space is empty or full, ideal or real, is the subject of an historic controversy between Newtonians and Leibnizians. Cf. *The Leibniz-Clarke Correspondence*, ed. N. Alexander (New York, 1956).

or metrical properties of things. Place, on the other hand, is physical; it can be known only as the term of local motion. The space of a thing is synonymous with its internal dimensions, coterminous with them; the place of anything is not internal to it but external. The space of the world is the sum of all spaces in the bodies of the world.

Space does not answer the question *where?* but the question *how much?* e.g., how much greater is a billiard ball than a buck shot? Now the question *where?* is a reasonable and legitimate question, even though it cannot be answered in terms of quantity alone. Thus, our usual proposition that the sun is 93 million miles distant from the earth is more than merely quantitative in character. Were it only quantitative, the proposition would simply say that a quantity is 93 million miles. But such a strictly quantitative proposition by itself would be meaningless to express a physical state of affairs. In order to make it meaningful, it is necessary to add physical references like the sun and the earth. It is necessary to say that the *sun* is 93 million miles distant *from the earth,* or something to that effect. Quantity, the answer to the question *how much,* cannot by itself respond to the question *where.*

But once we know — through the general physical knowledge which logically precedes the more refined and mathematical-physical study of nature — what we mean by *where,* we can supplement our general knowledge by the exact and metrical reports of matter available through modern physics. Once we know place as a physical measure we can learn more about it through the mathematical techniques that enable us to measure and refine but do not by themselves tell us what we are measuring and refining. This is another example of the relation between the general science of nature and mathematical physics. The second, as physical knowledge, specifies and clarifies what the first knows only in a vague and general way.

c. *Place, order, and final causes*

Aristotle held to an immobile earth to which heavy bodies were inclined by nature; in this same view, light bodies tended upward. Both type of bodies, it was argued, were seeking their natural places. After Copernicus, Kepler, and Galileo had overturned this earth-centered cosmology, Newton advanced another view that still retained an immobile reality. This immobile was absolute space which later came to be regarded as the ether, the immobile medium for planetary and stellar motion and the carrier of electromagnetic waves like light coming from the stars. But when experimental evidence failed to indicate the motion of things in an immobile ether, Einstein taught us that mathematical physics has no ground for accepting any physical reality as absolutely immobile. This step took cosmology a long way from the view there are immobile natural places for various kinds of things to which such things tend, in local motion, as to their final cause. Whatever may be argued in behalf of place as a final cause, Aristotle, with his immobile earth, was radically wrong in what he assigned as the fixed natural places of things. But if he was in error here about *what* the natural places of things are, was he equally wrong in arguing *that,* whatever they be, there are natural places to begin with?

The final determination of this whole question belongs to cosmology, the modern analogue of Aristotle's work *On the Heavens,* and not the modern substitute for his *Physics.* Cosmology makes a physical study of the universe-at-large. The issue, raised by Copernicus and other successors to Aristotle ending with Einstein, is relevant only in part to a general science of nature which treats mobile being at a universal level and has no warrant to discuss the absolute natural places (if there are such) for specific kinds of natural things. In the light of modern science, what are the data for a twentieth-century examination of the question of natural place?

In approaching natural place, at a level more generic than the specialized sciences bring to focus, the data are first the reality of nature, and second, the observed fact of the local order in our cosmos. To begin with the second of these data, such local order has to be accounted for, and if chance, being disordered, cannot explain order, recourse must be had to place as a final cause. *Without naming what the natural places of things are and whether they are absolute or relative, it must be urged that mobile beings, operating naturally (our second datum), move locally as they do in order to achieve, within the given circumstances, an environment most suited to their natures in the cosmos;* again, under whatever circumstances they are operating, locally moving bodies tend to surroundings most conducive to their fulfillment or (in Whitehead's language) satisfaction;[18] locally moving bodies seek what is most fitting for their destinies in an overall ordered world. In this sense, there is still room for natural places even after the lessons we have learned from the theories of relativity. In fact, the general theory of relativity, which has been compared

[18] *Process and Reality* (New York, 1957), p. 29; cf. also J. Weisheipl, "Space and Gravitation," *The New Scholasticism,* XXIX (1955), 175–223.

to Aristotle's theory of natural place,[19] would support the view that cosmic processes are conditioned by the character of their neighboring space. But this evidence, based upon specialized science, should be considered here as only a footnote to our main contention.

The foregoing argument is rooted in the reality of local order and the need to explain that order through a type of cause never encountered in mathematical physics, the final cause. In claiming that in local motion, at any one time or in any one region and under given circumstances, mobile beings seek an environment most suitable to them as parts of an ordered world, our conclusion is compatible with the relativistic denial that there is any absolutely fixed reality, like Newtonian space or the ether. It is being argued only that, under given conditions, there are natural places for various kinds of things. The division of place into the absolute and the relative is a distinction of the generic, so to speak, into its species; such an issue is outside the general science of nature which deals with place in general and can claim at most to establish *that* there are natural places without pretending to say what these are, for various kinds of bodies, and whether they are absolute or relative. If specialized science decides in favor of relativism, this view does not destroy the principle that there are natural places. It simply denies that anything is absolutely and for all time a fixed place, and we then have to apply literally the view that natural places depend upon the given and varying circumstances of cosmic history. Such a view leaves intact the general theory of natural places but only makes such places relative to given temporal epochs and other given conditions in a world where, even within a relativistic perspective, there is always an overall local order.

V. TIME, MOTION, AND QUANTITY

a. Time is not motion

All mobile being endures, and in our study of nature, time is bracketed with place (in mathematical physics, space) as a common characteristic of motion. In asking the question *where?* we refer an object to a place, and in so referring and thus using a "reference-system" we measure the mobile being. The question *when?* also involves putting an event into a larger "reference-system," in our terrestrial conventions, a day, month, year, etc. Days, months, and

[19] M. Jammer, *Concepts of Space* (New York, 1960), pp. 17–18; cf. also C. Lanczos, *Albert Einstein and the Cosmic World Order* (New York, 1965), esp. p. 102.

years come and go, and at first sight time would seem to be a kind of motion.

But it would be a mistake to identify time with any motion. In the first place, time is common to quantitative motion, qualitative change, and local motion. *All such motions involve time.* While each of these motions is going on, the same time is passing as our clocks or other time-tellers can show, and far from being any particular motion, time is something that all motions have in common.[20]

Second, motion can be slower or faster. A slower motion is one that covers a given space in a longer time, while a faster motion is one that covers the same space in a shorter time. If time were motion, such expressions would have to be altered to read that a slow time is one that covers a given space in a long time, etc. In other words, time would be measured by time. But leaving aside the problems raised by relativity theory, time, at least on earth, does not go faster or slower; time is (at least relatively) a constant, and it is the motions, which take time, that go faster or slower.[21]

But although time is not the same thing as motion, time is never without motion. It is only because a mobile being is now here and now there that we are aware that time has passed. *If everything, including ourselves, were absolutely immobile, we would be unaware of the passage of time and hence unaware of time's reality.*[22] After a period of sleep, we are aware that time has passed because things have changed around us; the sun is rising, for instance, or the hands have turned on our clock. The duration of what is at rest in the world is determined by the motions of things around it.

We become aware of motion and of time in the same experience. Even in darkness, when we may be lying still in our bed unaware of physical motions about us and within our own bodies, there is at least a succession of images passing before our mind, and in recognizing this succession, we are aware also of time. In perceiving motion, we perceive time; and in perceiving time, we perceive motion. The two are correlative.[23] Hence, it may be concluded that our definition of time will have to include the reference of time to motion without, however, making time and motion absolutely the same

[20] *Physics,* Bk. IV, ch. 10, 218b, 10–15; *Commentary on the Physics,* Bk. IV, les. 16, n. 568.

[21] *Physics,* Bk. IV, ch. 10, 218b, 14–19; *Commentary on the Physics,* Bk. IV, les. 16, n. 659.

[22] *Summa contra Gentiles,* Bk. I, ch. 55.

[23] *Physics,* Bk. IV, ch. 11, 219a, 4; *Commentary on the Physics,* Bk. IV, les. 17, n. 572; cf. the treatment of time and successive acts of angels in the *Summa Theologiae,* I, q. 53, a. 3; q. 63, a. 6, reply 4.

reality. Our definition of time must show how time is related to motion and yet how the two differ from each other.

b. Time and quantity

But there are other requirements that our definition will also have to satisfy. Time involves motion to the extent that motion is subject to being spread out or quantified. In watching a leaf being blown across the yard by the wind, the mind perceives that the object is first in *this* part of the yard and, as the motion continues, in *that* part. There is in some way a priority and posteriority between this part of the trajectory of a moving body and that part; i.e., the thing in motion is first in a prior part of the trajectory and then in a posterior part. Such an order between the prior and the posterior in this context is a quantitative order. It is a relation like that between two parts of a line in space. *Priority and posteriority here do not mean temporal priority and posteriority, for they would then beg the question; they mean rather spatial or geometrical priority and posteriority.*[24] Hence, it is not correct to say that time involves motion according to a *before* and *after,* because *before* and *after* in their common English usage can connote time itself. They are defined by time, and if they were included in our definition of time, they would render our definition circular. Priority and posteriority, as in our example of the leaf which is now in *this* part of the yard and now in *that,* are of a local or quantitative or geometrical character. The leaf is in the prior part of its trajectory and, as the motion becomes more complete, it is in the posterior part; such an order in the parts of the pathway of a moving body makes us aware of time.

There are in fact three kinds of priority and posteriority that might be confused. In the first place, there is the *temporally* prior and posterior, the *before* and *after,* which are the past and the future of time itself and which cannot be included in our definition without begging the question. Second, *motion* itself has a kind of prior and posterior insofar as a moving thing was previously in potency and later in act. The prior in motion is potency by comparison to the posterior as act. But once again this is not the meaning of the prior and the posterior in our definition of time. The prior and posterior which are going to occur in our definition are a third type. They are the local or *quantitative* prior and posterior, the order among the quantitative parts in the trajectory of a mobile being. Motion, it

[24] *Physics,* Bk. IV, ch. 11, 219a, 13–14; *Commentary on the Physics,* Bk. IV, les. 17, n. 580.

was argued, makes us aware of time, and we usually measure time by a uniform local motion, like the relative motion of the earth and the sun, both because such motion most clearly involves quantity, hence measure, and because such motion is regular.

VI. TIME AND NUMBER

a. We number the prior and posterior

So far, then, our inductive search through general experience has yielded two items for our definition of time. Time involves *motion,* and time refers to the *prior* and the *posterior* in the pathway of a moving thing.

There is yet another element that our definition must include. When we are aware of time to the extent that we distinguish the prior and the posterior in motion, we are in some way actually counting the parts of quantity traversed by a motion; we are saying that this part, as the motion proceeds, is first or prior and that this other part is second or posterior. *We recognize the prior and the posterior by numbering them, saying that the one is first and the other is second.*[25] Since the motion is continuous, there is always a fraction that could have been counted in between the prior and the posterior we choose to count. It is, of course, not necessary to use distinct numbers like "first" and "second" in order to be aware of time, but there is always a vaguely known succession of parts, a confused awareness of prior and posterior quantitative parts, an implicit counting of a first and at least a second in the trajectory of a moving body.

There are at least two parts involved in time: the *past* which corresponds to the prior part of a trajectory already covered by the thing moved; and the *future* which corresponds to the posterior part of the trajectory that the motion has yet to traverse. When we number the parts of such a trajectory, recognizing that the *here* is first and the *there* is second, we are aware of time. *Time, then, is a number or measure of motion according to the prior and the posterior.*[26]

b. Time is to a line as now is to a point

It may be useful to consider time as being somewhat similar to a line. Before beginning, however, we ought to emphasize that we are here merely comparing time to something we already know from

[25] *Commentary on the Physics,* Bk. IV, les. 17, n. 580.

[26] *Physics,* Bk. IV, ch. 1, 220a, 24–25; *Commentary on the Physics,* Bk. IV, les. 17, n. 280; *Summa Theologiae,* I, q. 10, a. 1.

mathematics, i.e., a line, and there is no pretense that our comparison is anything more than a pedagogical device, a dialectical model. *Time, unlike a line, exists only successively but never with all of its parts simultaneous. A line, on the other hand, has its parts simultaneously present. Hence there is a decisive difference between time and anything merely geometrical.*[27]

In the light of our comparison, the *now* or instant is like some point on a line.[28] One part of the line represents the past and the other the future. But what do we mean by the *now?* Is the *now* the same thing as the present? Is the *now* truly a part of time, or does it have some other status? A weighing of these questions will help us to a better understanding of what time is.

Unlike the point on a line, the *now* is always flowing.[29] If a point were considered to undergo an imaginary motion, it would be regarded from one angle as the same point that was being moved; but to the extent of being in motion, the point would likewise always be different. It would be the same subject with constantly changing relations.[30]

So also with the *now*. The *now* does not go out of existence in the past in order to come back into existence in the future. Time is like our line generated by our point in imaginary motion, and the *now* is like the point itself. Time is generated by the *now* flowing. The *now* has a continuous existence as it flows through time; but as always flowing, this continuous existence must always be different. This is the reason why the *now,* as flowing, can unite the past to the future in a continuous flow and still leave them differentiated. How is this twofold function possible on the part of the *now?*

The *now* is like a moving point; time is like a line. In the framework of another comparison, time is related to motion as the *now* is related to mobile being.[31] Hence, as mobile being is twofold in character, so is the *now*. Throughout any motion, there is something of the mobile being that remains constant in time, thus giving to time a continuity like that of local motion itself, but there is also something that does not remain constant. The twofold character of the *now* can be brought out best if we remark that the *now* is the

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[27] *Summa Theologiae,* I, q. 7, a. 3, reply 4.

[28] *Physics,* Bk. IV, ch. 13, 222a, 14–16; *Commentary on the Physics,* Bk. IV, les. 18, 585.

[29] *Summa Theologiae,* I, q. 10, a. 4, reply 2.

[30] *Summa contra Gentiles,* Bk. II, ch. 36; *Summa Theologiae,* I, q. 10, a. 4, reply 2.

[31] *Physics,* Bk. IV, ch. 11, 219b, 26–28; *Commentary on the Physics,* Bk. IV, les. 18, n. 585; *Summa Theologiae,* I, q. 10, a. 4, reply 2.

term of the past and the principle of the future. Hence, the *now* can have a twofold function.

c. The present

There are two parts of time, the past and the future, and the *now* both unites and divides them. The present is not the same as the *now,* and neither is it a part of time distinct from the past and the future. The present day, as a reader is taking in these lines on this page, includes some of the past and some of the future, going back, say, to the beginning of today and continuing until midnight tonight. The same judgment could be made about the present hour; it includes some of the past and some of the future. The same could be said of the present minute or present second or the present subdivision of a second, however small it be made. Returning to our analogy with the line, there is no smallest part of time just as there is no smallest and indivisible part of a line.[32] *What is called the present day or present hour or present second includes a portion, more or less great, of both the past and the future.* What is called the present, without designating the interval, is some indefinite portion of the past, however great or small, joined with some indefinite part of the future, again however great or small. Such a present held before the mind, because of reason's synthetic reach into the past and the future, is often called the specious or *psychological* present. But if time involves a continuous flow and may be likened to a line, there is no smallest or indivisible part of it that can be isolated as the *physical* present.

VII. THE NOW AS TWOFOLD

a. The two functions of the now

The *now* is thus not the same thing as the present. The *now* is not, as is the present, a synthetic unity of part of the past with part of the future. In fact, the *now* is not even a part of time, just as a point is not part of a line.[33] As a point on a line divides two parts of a line from each other and also joins them but is not part of the line itself, so the *now* divides times into its two parts, the past and the future, without itself being a part of time.

As a point both distinguishes two parts of a line from each other and continues them with each other, so does the *now* in regard to time. *It is the term of that part of time which we call the past and*

[32] *Commentary on the Physics,* Bk. IV, les. 19, n. 594.
[33] *Ibid.,* Bk. IV, les. 18, n. 592.

the principle of that part which we call the future. The only difficulty with our analogy is that the point is immobile but the *now* is always flowing.

b. Reason and the two functions

In speaking of the future, the mind regards the *now,* which in reality has a twofold character of terminating the past and opening the future, in only one of its functions, namely, as the principle of time to come. In considering the past, the mind considers only the function of the *now* as terminating the time that has been. In considering the present day, once more reason considers, at the beginning of the day, only the function of the *now* as a principle and at the end of the day only the function of the *now* as a term. Similarly in considering any period of time, past or future, the mind considers, first, only the opening function of the *now* that begins the period and, second, only the closing or terminating function of the *now* that ends it. *In abstracting for its consideration any portion of time, reason views an instant or now under only one of its two functions; reason considers a now either as terminating the past or as beginning the future.*[34]

The *now* is not the present. It is not even a part of time but rather a limit of time. It is related to time as a term is related to that which is terminated or as a principle is related to that which flows from it.[35] It divides and continues the temporally prior and the posterior, which are known first from the prior and posterior in a motion's trajectory. As that according to which motion is measured, the *now* determines the prior and posterior. The *now* is thus a kind of divider to determine what we are to take as prior and what as posterior in our numbering of motion and hence our determination of time.

VIII. KINDS OF NUMBER

a. Number as something primary

Number is involved whenever we affirm or deny that one thing is greater or less than another in the physical world. To claim that one person is taller than another is to say that there are more units of measurement in the first than in the second. To think of an elephant as heavier than a mouse is again to refer to a difference in the num-

[34] *Summa Theologiae,* I, q. 10, a. 4.

[35] *On the Power of God,* q. 3, a. 17, reply 3; q. 4, a. 2, reply 13.

ber of weight units which each thing contains. In a similar way, we judge motion to be more or less complete by that peculiar kind of number which is time. Motion as corresponding to a prior part of its trajectory is complete, and as represented by the posterior part of its pathway is incomplete.

It should be stressed, however, that we are not measuring the prior and the posterior when we tell time; to measure prior and posterior parts of quantity is the task of a geometrician and the result is some sort of spatial measurement and not a determination of time. Time is a measurement of motion, not of the prior and the posterior in quantity. Rather than being a measure of the prior and the posterior, time measures *according to* the prior and the posterior, and what it measures in this way is motion.

b. Imprecise number

Unequipped with a watch or any other fairly precise timepiece, the mind naturally numbers motion according to priority and posteriority but only in an imprecise and highly approximate way. It may not use actual and explicit numbers. But it is implicitly and vaguely employing number, for otherwise it would not be aware that time is passing. It says *this* part of motion occurs first and *that* part at least second. *The mind is aware of the parts of time which are determined by the parts of motion which in turn are determined according to the prior and the posterior in magnitude, and to be aware of parts is, at least in an implicit form, to number.* Our clocks and chronometers do not abolish the mind's natural, if implicit, numbering of the parts of time. They refine and imitate it, like an art building on nature. We surely have to know what time is before we can make sense of the written numbers on a dial.

c. Applied number

Number can have two senses. It may be pure or abstract number like *ten* or a *dozen,* or it may be applied or concrete number like *ten teeth* or a *dozen eggs.* Time is the second kind of number; it is not a number abstracted from the thing numbered but is a number existing, as it were, *within* the thing numbered. *By analogy to the teeth or eggs which are numbered things, the concrete parts involved by motion are measured by time.*[36] If time were pure number, it would be strictly a mathematical reality rather than anything physical and natural. If this were so, time would apply to quantified sub-

[36] *Summa Theologiae,* I, q. 10, a. 6; *On the Power of God,* q. 9, a. 5, reply 6.

stance but not to the qualities and motions which complete the structure of physical things. But time as a number measures the motions of quantified substances; it is not limited, as is arithmetical number, to quantified substance itself.[37] Time numbers or measures motion rather than the purely quantified, the simple prior and posterior of place and space. Time is the number of motion according to the prior and the posterior. In other words, time does not pertain to discrete (arithmetical) quantity, but to continuous (geometrical) quantity. The reason why this is so is that the reality measured by time, namely motion, involves the continuum. Number applies to the parts of a continuum, which will be studied more fully in the next chapter.

IX. TIME AND REALITY

a. Time and existence

Time exists in its most perfect form in the measuring intellect of man. But time outside the mind must have at least an imperfect existence.[38] It cannot be passed off merely as something we impose on the real by the structure of our mind.

Number itself has a foundation in reality, since there are countable things in the real world which the mind does not create but only knows by numbering them. The mind does not create the *three* of the clover leaves, but in numbering the leaves merely discovers how many there are.

Now it is true that there could be no actual enumeration of the parts of time if there were no human soul. Nevertheless, even if there were no human souls, there would still be a *numerability* in the prior and posterior parts of a motion's trajectory, and such numerability is the foundation for time. *To this extent at least, time has an imperfect existence outside the mind. It has a foundation there.*

Another comparison might help. *Just as there would be no sensibility in things if nature did not contain animals that could sense — for the existence of the sensible as a potency that could never be actualized would be a contradiction*[39] *— so there would be no numerability in the parts of motion if nature did not provide in some way a human mind that could number the numerable and thus reduce the*

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[37] *Physics,* Bk. IV, ch. 12, 220a, 26–220b, 14; *Commentary on the Physics,* Bk. IV, les. 17, n. 581.

[38] *Commentary on the Physics,* Bk. IV, les. 23, n. 629.

[39] *Summa contra Gentiles,* Bk. II, ch. 22.

potency to a state of act.[40] To the extent that the parts of motion are numerable, time is real; but to the extent that there is no acual numbering, time is only imperfectly real. Without the mind, motion itself would have only an imperfect existence, since the only actual existent in motion is an "indivisible"[41] corresponding to the *now* of time.

But the *now*, it was earlier argued, has a twofold character; it is a unifier and divider. This duality on the part of the real *now* is the actuality that can be assigned to time outside the mind. Such an actual *now* divides the numbers and unites them. On this basis it can be claimed that time is foundationally or materially in things, while being formally in human reason which, in following the two-way character of the *now* into the duality of number, is aware of the past and the future.

b. Time and relativity

The measure of motion that we call time depends upon the prior and the posterior in quantity. These two characteristics of extension are most apparent in local motion, and hence such motion is employed in the measurement of time, e.g., the motion involving the earth and sun in nature and the motion of the hands on a clock in the world of art. But the theory of relativity is built on the experimental evidence that there is no absolutely fixed frame of reference, no absolutely fixed prior and posterior in physical quantity, and hence no absolute time. According to Einstein's theory, then, the distinction between the prior and the posterior is not absolute; it varies according to the state of motion of the observer, so that two light signals which are taken as simultaneous for one such observer are not so for another in a state of motion with respect to the first.[42]

But as in the difficulties over the relativity of place (space), *the resolution of this question does not belong to a general science of nature.* It is a special problem belonging to specialized science. As remarked in treating relativity, when we met it in regard to place, the distinction of time into the absolute and the relative is a kind of division of a genus into its species. But the central questions of this chapter have been place as place and time as time, questions

[40] *Physics,* Bk. IV, ch. 14, 223a, 21–27; *Commentary on the Physics,* Bk. IV, les. 23, n. 629. Cf. P. Conen, "Aristotle's Definition of Time," *The New Scholasticism,* XXVI (1952), 451 ff.

[41] *Commentary on the Physics,* Bk. IV, les. 23, n. 629.

[42] For an excellent presentation of this argument, see R. Feynman, R. Leighton, and M. Sands, *The Feynman Lectures on Physics* (Reading, Mass., 1963), ch. 15.

more general than those of Copernicus, Newton, and Einstein. From the opening chapter of this book, a conscious procedure for relating the general science of nature and the specialized sciences has been followed by assigning more generic issues to the former and more specific issues to the latter. This procedure, it was claimed, is based upon the very nature of human reason and is hence not an arbitrary decision.

CHAPTER VII
MOTION AND THE CONTINUUM

I. EVERY MOBILE BEING IS A BODY: A DEMONSTRATION

There are at least two ways of dividing "motion." One is to divide it into its species like generation and destruction (substantial change) and local motion, alteration, and growth (accidental change). Accidental change is gradual, whereas substantial change, though preceded by accidental modifications, is instantaneous when it finally takes place. Only accidental change is motion in the strict sense, as such expressions are normally employed. Therefore, all motion is change, but not all change is motion. One would not normally call death a motion, though accidental changes precede it. Another way of dividing motion is according to its quantitative parts, and the reason why a general science of nature can consider this question of the quantitative parts of motion is that: (*a*) every mobile being is a body; and (*b*) a body is a substance endowed with quantity.

Unless everything mobile were corporeal, it would not have a gradual character with prior and posterior parts. When, in earlier chapters, the subject of the general science of nature was identified as material being, the term was taken loosely and improperly. That the mobile is the material or the corporeal must be proved. The subject of a science of nature is mobile being, not material being, if our definition of nature is accepted.

That every mobile being is a body can be demonstrated by the following syllogism:

> Whatever is composed of parts is a body.
> But every mobile being is composed of parts.
> Therefore, every mobile being is a body.

The first or major premise is the definition of a body. The second or minor premise is evident from the definition of motion. For what is in motion is partly in act and partly in potency. *Hence, everything mobile must have (at least two) parts; it must be quantitative.* Our present chapter is concerned with the number of these parts. It is concerned with what is implied in the conclusion of the foregoing syllogism. How many parts are there in a physical body? This is the problem of the continuum.

II. TWO DEFINITIONS OF THE CONTINUUM

a. The material definition

There are two definitions of the continuum. Each of them must be stated, explained, and defended. The more common and more easily understood definition defines the continuum in terms of its material cause: *The continuum is that which is divisible into what is always further divisible.*[1]

b. The formal definition

The second definition states that *the continuum is that whose terms are one.*[2] This definition, which will need some explanation to be understood, proceeds through the formal cause because every term is a form and vice versa. Throughout this chapter, the first definition will be called the material definition and the second definition will be termed the formal definition.[3]

III. THE CONTINUUM IS ALWAYS DIVISIBLE

a. Continuum not made of indivisibles: Thesis

In order to explain and justify the material definition, it will be necessary to show that a continuum is not made up of indivisibles, i.e., a solid is not composed of planes nor a plane of lines nor a line of points. In other words, a continuum is not made up of ultimate parts which are incapable of being further divided. If a continuum were not divisible into what is always further divisible, the only

[1] *Physics*, Bk. VI, ch. 1, 231b, 15–16. There are also many references to this definition in the works of St. Thomas; cf. e.g., *Commentary on the Physics*, Bk. I, les. 3, n. 22; *Summa contra Gentiles*, Bk. III, ch. 12; *Commentary on On the Heavens*, Bk. 1, les. 2.

[2] *Physics*, Bk. VI, ch. 1, 231b, 17; cf. also for instance, *Commentary on the Physics*, Bk. IV, les. 21, n. 613; Bk. VI, les. 1, n. 751.

[3] For the difference between a material and formal definition, cf. e.g., *Commentary on the Physics*, Bk. II, les. 15, n. 274, and esp. *Commentary on the Sentences*, Bk. IV, d. 3, a. 1, q. 4, 1.

alternative would be to conclude that divisibility must eventually be exhausted, leaving remainders that are no longer capable of division and hence indivisible. But as will be seen, no such remainders are possible. *If it can be shown that a continuum is not composed of indivisibles, the only conclusion is that division of the continuum will never resolve into indivisibles, and hence that indivisible remainders will never be obtained through division.*

b. Points do not form a line: Proof

In order to make our inductions more forceful, let us consider only that simplest kind of continuum, a line; and in any applications to mobile being let us allow a mathematical division of any continuum after physical division is no longer possible. If a line were divided until divisibility would be exhausted and indivisibility were reached, a line would be made of indivisibles, and we could expect to put our indivisibles together to get back the original line we divided.

But we could never do so. For the indivisibles resulting from our division would have to be points and points cannot be added together to form our original line or any other line. The point *B*, for instance, that we would add to *A* would yield no more extension than the original point.[4] It cannot touch the original point with one part of itself and leave another part spread out to touch some other point and thus produce a line. *For points, being indivisible, have no parts. Any point that would touch another would totally coincide with that other without ever stretching out beyond it.* No matter how many points were "strung together" in this way, they would pile up on top of one another without ever extending, even to an infinitesimal degree, beyond the original point. Therefore, because indivisibles can never be put back together again to yield the original line, a line cannot be divided until it yields indivisibles; and hence the line is divisible into what is always further divisible. This conclusion must also hold of any continuum in the physical world.

c. Continuum made of smaller continua

As a line is not composed of points but of smaller lines, so every continuum is composed of smaller continua. *A plane is composed of planes, not of lines, and a solid is composed of solids, not of planes.*[5]

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[4] *Commentary on the Physics,* Bk. VI, les. 1, n. 752.
[5] *Commentary on On the Heavens,* Bk. III, les. 3, 4.

A plane cannot be divided until the parts finally become so small that they are merely lines, and a solid cannot be sliced so thin that the remainders of its division are planes. Any continuum is divisible into a potential infinity of parts;[6] but because of the further divisibility of each part, the multitude of the parts can never be actually infinite.[7] Each part, no matter how small, is always divisible. This conclusion likewise must hold of quantity, as quantity, in any mobile being.

IV. A CONTINUUM IS THAT WHOSE TERMS ARE ONE

a. A line contains actual parts

The second and formal definition of the continuum is more difficult to expound, partly because comparatively little attention has been paid to it. This formal definition defines the continuum as that whose terms are one. It might be approached by showing that since the "number" of parts in a continuum, e.g., a line, is not actually infinite, it must be actually finite. Although the "number" of parts on a line is not actually infinite, there are truly actual parts on such a continuum. There are at least two halves on a line, and even smaller parts as our knowledge of fractions would show. *The only way in which the lengthening of a line can be explained is that actual and not merely potential parts are added to the original line; the longer line contains more actual parts than the shorter one because it is actually, and not merely potentially, longer.* In brief, there is ample evidence that any continuum does have actual parts, no matter what it may contain in potency.[8]

The precise number of actual parts in a continuum, if such a question makes any sense, need not bother us, at least at present. Later on, it will be seen that such a question is meaningless. The point here is only that actual parts are present in any continuum, a line, a plane, or a solid. The geometer, in finding the two halves of a given line, does not bring the halves into existence.[9] He simply finds out what and where they are. The parts are there, actually, before he studies them.

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[6] *Commentary on the Physics,* Bk. VI, les. 4, nn. 778–779.

[7] *Summa Theologiae,* I, q. 7, a. 4.

[8] *Summa contra Gentiles,* Bk. II, ch. 49; *Commentary on Sense and the Sensate,* 15; *Commentary on On Generation and Corruption,* Bk. I, les. 4, n. 5; *Exposition of the Posterior Analytics,* Bk. II, les. 10; *On Truth,* q. 22, a. 14.

[9] "For a point is nothing other than a certain division (*quaedam divisio*) of the parts of a line." *Commentary on On the Heavens,* Bk. III, les. 3.

b. The actual parts are distinct through indivisibles

By the very nature of quantity, the parts, e.g., the parts of a line, must be distinct in themselves and distinct from other parts.[10] There can be no overlapping of the parts, no running together or compenetration. If the parts actually present on a line overlapped each other, they would lose their identity. For in the very nature of quantity, the position of any part is of the essence of that part.[11] Two equal straight lines are different only in position. Likewise each part of a line (or of any other continuum), to be distinct, must have an individual position, shared by no other part. Looked at from another angle, parts that overlapped one another would, when put together, fail to equal the whole. Hence, there are actual parts on a line in such a way that each part is distinct in itself and distinct from neighboring parts. The same holds for other continua.

Because of the presence on a line of actual parts that do not compenetrate each other but remain distinct in themselves, it is necessary to hold that there are indivisibles actually present within a continuum.[12] These indivisibles, e.g., the points within a line, are not parts of a continuum; for in accordance with our previous conclusion, there are no such indivisible parts. The indivisibles are terms of actual parts; they are related to the parts of the continuum as form to matter. The indivisibles here in question have a twofold function. They terminate each actual part in itself, and they continue each part with the neighboring part. They are indivisible divisors between the parts so that any two actual parts at, say, the interior of a line have a common term. Once more this conclusion is not merely mathematical but also physical, to the extent that every mobile being is quantified. Moreover, what is said of a line can also be extended to the analysis of a plane and a solid.

It is easy to misunderstand the conclusion we are trying to attain. The indivisible divisors, e.g., the points in a line, the lines in a plane, and the planes in a solid, are not parts of the line, plane, and solid; if they were parts, any continuum would be composed of indivisibles, and we have already established that this is false. The indivisibles of any continuum are related to the parts rather as terms; for example, the points on a line terminate (and continue) the parts, and similarly lines terminate (and continue) the parts of a plane

[10] *Commentary on On the Trinity of Boethius*, q. 2, a. 2, reply 3, English transl. by A. Maurer, *The Division and Methods of the Sciences* (Toronto, 1953).

[11] *Ibid.*, q. 4, a. 2, reply 3.

[12] *Exposition of the Posterior Analytics*, Bk. II, les. 10.

and planes terminate (and continue) the parts of a solid. That is why the formal definition of the continuum reads "that whose terms are one." Two neighboring parts at the interior of any continuum have a single common term. Terms of such neighboring parts are not merely together, not merely adjacent or contiguous if such language makes any sense. They are the same. The terms of a glass and the water inside of it are contiguous but not the same. For the parts of any continuum the terms are identical.

c. *The size of actual parts*

In explaining that every continuum contains actual parts kept distinct from each other by indivisibles, hardly anyone can get very far without encountering a question as to the size of the actual parts: How many actual parts are there? How big is the minimal actual part?

Such questions are almost inevitable, and in order to approach them properly, it is first necessary to identify the kind of part here being discussed. The question here concerns so-called proportional or undesignated parts that make up the being of any continuum, e.g., the being of a line. We are dealing with parts that constitute a line in its *entity*.[13] The concern here is not with the designated parts used in order to *measure* a line. Such parts are capable of being determined by us in their number and in their size. In a twelve-inch line measured by a foot ruler, there are obviously twelve designated parts.

The parts of interest in this chapter are so-called proportional or undesignated parts, the parts which make up the line in its *real entity* by contrast to the parts we use as *arbitrary units* of measurement. How many such actual proportional parts are there on a line? The answer, if there ever could be an answer, pivots upon the size of the smallest actual part of a line.

But such a minimal part with respect to the whole has no actual but only virtual size.[14] In dealing with a principle, such as a unit, we do not ask the kind of question we ask about numbers of which the unit is a principle.[15] We can ask how many people are in a room and get a reply like "fifty." But we do not ask *how many* in respect to one person only. The one is a principle; the fifty are an effect. Just as a principle contains the effects that issue from it but in a mode differing from a mode of existence these effects shall have as

[13] John of St. Thomas, *Curs. Phil., Phil. Nat.,* I, P. Q. XX, a. 1, II, 416 (ed. B. Reiser).

[14] *Ibid.,* a. 2, II, 424.

[15] For the relation between unity and number, cf. e.g., *On Truth,* q. 2, a. 1.

effects, so that principle of a line which is the minimal proportional part of the line in question is not a line in the same way in which the effect is a line. It is after all a principle, and things have a different character in their principles than they do in themselves. Size and genuine measurement refer to designated, not entitative, parts.

d. The number of parts is potentially infinite

Our conclusion, leading to the formal definition of the continuum, that there are actual parts on a line, finite in their "number," does not contradict the previous conclusion, based on the material definition, that *the "number" of parts of a continuum is infinite in potency.* The actual parts are in potency to division, *ad infinitum.* In discussing the formal definition of the continuum, we have been concerned with parts in act, whereas the material definition of the continuum bears upon parts in potency. The parts in act can be divided *ad infinitum.* Hence, there is no conflict between the insistence that the parts in a continuum are actually finite and a previous decision that they are potentially infinite.

V. THE CONTINUITY OF MOTION

a. The parts of motion follow the parts of magnitude

The continuum in the order of magnitude or quantity yields insight into the continuum at the level of motion and of time. *Motion is, taking it now in its precise meaning as local movement, continuous because the magnitude that it traverses is continuous.*[16] Divisibility and indivisibility characterize motion in the same manner as they characterize the magnitude through which the motion passes; and from the continuity of motion there is evidence of the continuity of time. The continuity of magnitude is thus the fundamental type of continuity. Motion is continuous because magnitude is continuous, and time is continuous because motion is continuous.[17]

Wherever there is motion, in its precise meaning as local change, there are parts of motion: that is to say, a body in motion reaches its term successively and part by part. It does not go from relinquished to attained term in an instant. The successive parts of local motion correspond to the parts of the magnitude through which the motion passes. For local motion is a successive continuum, while magnitude as such is a simultaneous continuum whose parts are all actual at

[16] *Physics,* Bk. VI, 231b, 18 ff.; *Commentary on the Physics,* Bk. VI, les. 2, n. 758.
[17] *Summa Theologiae,* I, q. 52, a. 1; *Commentary on the Physics,* Bk. VI, les. 3, n. 766 ff.

once and not one after another.[18] Local motion traverses these parts.

The successive character of local motion is evident from experience. A body undergoing local motion does not reach its term in an instant but by degrees. There is a time when such a body is at rest in its relinquished term and a later time when it is at rest in the attained term. In between, there is also a time when it is being moved. To be in a motion and to have completed a motion are not the same thing. To be en route to Washington and to have arrived in Washington are different "states." Moreover, there is a midpoint en route and a quarter point, etc. Motion involves parts measured by the parts of the magnitude through which motion passes. This is true in all motion but can be seen best in local movement.

b. There is no indivisible moment

Nothing can be moved in an indivisible "magnitude."[19] The indivisible is a term, and a mobile being in such a term is at rest, not in motion. If a body moves through a magnitude, such a magnitude must be divisible; it must be a whole composed of parts. On the other hand, the term of a motion, where motion is over, is indivisible;[20] and it is indivisible precisely because it terminates the motion, like a point on a line.

Just as a line is not composed of indivisible points but of lines, so motion is not composed of indivisible moments but of motions. If motion were capable of division into indivisible moments, the possession of an attained term would take place without motion. A thing could then go from *here* to *there* in an instant. The state of having been moved could then exist without the previous state of being moved.[21] In other words, if motion were a series of indivisible moments, a moving being would be at rest in every one of the stages of motion. To reduce motion to a series of non-motions would really be a denial of motion.

VI. THE CONTINUITY OF TIME

a. Time is not composed of instants

As magnitude is not composed of indivisible quantities and as motion is not made of indivisible moments, so time is not composed

[18] *Summa Theologiae,* I, q. 7, a. 4, reply 1.

[19] *Physics,* Bk. VI, ch. 1, 232a, 7–9; *Commentary on the Physics,* Bk. VI, les. 2, n. 762.

[20] *Commentary on the Physics,* Bk. VI, les. 7, nn. 821–822.

[21] *Summa Theologiae,* I, q. 53, a. 1, reply 1.

of indivisible instants. In local motion, for instance, the traversing of the total magnitude requires a total time and the covering of part of the magnitude requires part of the time. Just as there is no smallest part of magnitude, so there is no smallest part of time, and since there can be no indivisible components of magnitude, neither can there be an indivisible ingredient of time. *Time is not composed of indivisible nows but of smaller times.* In short, if time is a measure applied to the prior and the posterior in motion, it can be argued that because magnitude is divisible, so is motion and so, finally, is time itself.[22]

b. The now is indivisible: A term and principle

The *now* according to our previous analysis is indivisible, and the same *now* is the term (*terminus ad quem*) of the past and also (*terminus a quo*) of the future. *If the "now" were divisible, spreading out as it were like a line in space, the past and the future joined by the "now" would compenetrate each other; something of the past would be in the future and something of the future in the past, because the past and the future would be mixed by the single and yet divisible "now" continuing them.* The *now* therefore cannot be divisible, stretching out so to speak across the span of time. If, on the other hand, it be denied that it is the same *now* terminating the past and opening the future, the two *nows* would have to be different and discrete. Time would then lose its character as a continuous flow. It would be an aggregate of *nows*. But it could not be an aggregate of indivisible *nows* any more than a line can be made of indivisible points.[23] If time were such an aggregate, things in time would not have a continuous existence.

c. There is no rest in the now

In an indivisible *now*, a thing is neither in motion nor at rest. Such contraries when applied to the *now* have no meaning. It has already been seen that since the *now* is indivisible there can be no motion in it, and since rest is the contrary of motion there can be no rest in the *now* if there is no motion in the *now*. Rest is possible only where there is motion. *Our conclusion can be reached in another way by insisting that a thing at rest is a thing which remains the same throughout a period of time, i.e., before a certain "now" and after it.*[24]

[22] *On the Power of God*, q. 3, a. 17, reply 24; *Commentary on the Physics*, Bk. VI, les. 4 (*passim*); *Commentary on the Metaphysics*, Bk. II, les. 10, n. 2354.

[23] *Physics*, Bk. VI, ch. 3, 234a, 4–8; *Commentary on the Physics*, Bk. VI, les. 5, n. 791.

[24] *Commentary on the Physics*, Bk. VI, les. 10, n. 856.

As a line must be between at least two points, so rest requires at least two *nows* with time in between them. Whatever is moved or at rest is moved or at rest in time.

VII. THERE IS NO PRIMARY MOMENT OR PRIMARY WHEN

a. Recapitulation: Motion is always gradual

By way of making a transition to the next topic in the division of motion, it should be recalled that motion (in its strict sense) takes place between two contrary and hence two positive terms; when a thing is in its attained term, it is no longer being moved but it has been moved. When a thing is in its relinquished term, the motion has not yet begun. Motion, as such, does not transpire suddenly between the terms but in a gradual and continuous manner, as experience reveals. Indeed, a locally moving body does not move as a whole out of its relinquished term but part by part. If, for instance, a body is moved from *A* to *D* along a straight line *ABCD,* in the beginning of the motion one part of the body in some way corresponds, let us say, to part *AB* of the line, and at a later time, a posterior part of the moving body corresponds to *AB,* a prior part of the line, while a forepart of the body in motion in some manner corresponds to *BC* and an even more prior part of the body corresponds to *CD*. Since motion in our example is actually going on, it is not proper to speak of a body or even part of a body as being *in* a certain place; but from our example, it can be strongly argued that a locally moving body according to part of itself is associated more with one part of a trajectory and according to another part of itself with another part of the pathway. *As transpiring between the attained and relinquished terms, a moving body shares in some measure in both of them according to different parts of itself. Motion in the strict sense is essentially an affair of parts.*[25]

b. Is there a first in any motion or any time?

It is possible now to raise some further questions concerning the various stages of motion. Is there a first part or first moment in any motion? It is apparent that when a thing has left its relinquished term behind, to some extent it has already been changed, and our question asks whether there is a first moment of such change, a primary state in which it would be true to say that there is a certain completion of

[25] *Summa Theologiae,* I, q. 53, a. 1, reply 1.

the change and before which it would be false to make this statement. Our question could also be put: Is there a primary *when* in motion? The term *primary* here is understood as in our previous discussions. It is not synonymous with essential. A thing is changed in an essential way when something of its nature has changed. *A thing is changed in a primary way when it is changed as a whole or as any completion, and not by reason of its parts. A primary "when" would be the first unit of time in which there is any completion of change, and before which there was no such completion; hence any change that takes place in stages, with one part of the motion taking place in part of the time and another part in another, would not have a primary "when."*

c. There is no first in motion or time

With regard to motion in the strict sense of the term, there is no primary moment, or primary *when*. There is no first moment or stage in which it would be true to say that a moving thing has changed and before which this statement would be false. There is no part of a trajectory for which we cannot find an earlier part and no part of time that we cannot find to have been preceded by an earlier time. No matter how early we examine a motion, it will be found that the mobile being, whatever it is, has already been changed earlier in some primary and essential way. There is no first completion of motion properly speaking, no first state of having been changed. In short, motion has no primary moment and time no primary *when*.[26]

VIII. THE FINITE AND INFINITE IN MAGNITUDE, MOTION, AND TIME

The finite and the infinite are found in a similar way in magnitude, in motion, and in time.[27] *In each case there is a number of parts actually finite but always divisible into smaller parts and hence potentially infinite.* Motion and time are like the lines of magnitude; the state of having been moved in the case of motion and the *now* in the case of time are like the points. As on a continuous line there is no part that is absolutely first or last, but always terminated parts that may be more and more finely divided by imaginary or mathematical division, if not by physical division, so there is no smallest part of motion nor smallest part of time.

Just as there is no first part of motion, so there is no first part of

[26] *Commentary on the Physics*, Bk. VI, les. 7, n. 822.

[27] *Physics*, Bk. VI, ch. 7 (*passim*); *Commentary on the Physics*, Bk. VI, les. 9 (*passim*).

rest or first *when* in which a thing is at rest.[28] But as the principles for proving these truths are the same as those employed above, the reader is left to determine them for himself.

IX. THE RELEVANCE OF STUDYING THE CONTINUUM

a. Zeno's paradoxes

The nature of the continuum, as discussed in this chapter, is not a mere dialectical exercise. The problem, and some would even say mystery, of the continuum is one of the oldest problems that have plagued Western thinkers from the Greeks down to the present time. In the ancient world, the name associated with the continuum is that of Zeno, whose study of quantity persuaded him that motion is really impossible and is hence only an illusion of our senses. Several arguments were proposed by Zeno, of which only one will be considered here.

Consider an archer shooting an arrow at a target. In order to reach the target, Zeno said, the arrow would have to go through an infinity of intervening points, for the multitude of points between the archer and the target is truly infinite. Even if the arrow were to go halfway to the target, it would have to traverse a line containing an infinity of points, and since the infinite cannot be traversed, our arrow could not even reach this halfway point. A fourth of the distance to the target also contains an infinity of points, and so does an eighth, a sixteenth, etc. *Even the smallest distance toward the target, being a line, contains an infinity of points according to Zeno's logic. Hence, because the infinite cannot be traversed, even the smallest amount of motion toward the target becomes impossible.*[29]

The mistake of Zeno's argument is to attribute an actually infinite character to the components of a continuum. Thus, he argued that any line, however small, between the bow and the target contains an infinity of pointlike units of composition. According to our analysis, the number of parts (and hence the number of their terminal points) on any line is infinite only in potency; actually it is finite. Hence the distance, as actually finite, can be traversed, and traversed indeed in a finite time. Zeno's mistake, therefore, was to attribute to a continuum an actually infinite character, whereas it is infinite only in potency. Zeno saw only the multiplicity of the continuum and ignored its unity.[30]

[28] *Physics*, Bk. VI, ch. 8, 239a, 10–11; *Commentary on the Physics*, Bk. VI, les. 10, nn. 855–856.
[29] *Physics*, Bk. VI, ch. 2, 233a, 21 ff.
[30] *Commentary on the Physics*, Bk. VI, les. 11, n. 863.

It is not necessary here to explain the rest of Zeno's arguments. All of them involve the same error as the previous one, the confusion of the potentially and the actually infinite, and hence all of them can be answered by using the same principle: i.e., the number of parts in a continuum, while potentially infinite, is actually finite.

b. Quantum theory

Another problem concerning the continuity of matter and of motion is of a quite different kind and takes its most emphatic form in that system of modern physics called quantum theory. This theory may be illustrated for present purposes by the Bohr theory of the hydrogen atom. The single electron which revolves about the hydrogen nucleus like a planet orbiting around the sun can be excited until it reaches orbits more and more distant from the nucleus of the atom. As the electron falls back from less stable outer orbits to more stable orbits closer in toward the nucleus, there is an emission of light in the form of packets of energy called quanta. This theory became a basis for explaining how various substances can be excited to emit radiation.

But how does the quantum theory, as illustrated by the Bohr atom, raise the problem of continuity?

It does so because the electron falling from an outer orbit to an inner one is thought to leap or jump across the intervening space. If you draw a series of concentric circles about some point representing the nucleus of a hydrogen atom, an electron revolving in some outer circle can, in an indivisible manner, leap into an inner one without going through the space separating the circles. So, at any rate, goes one interpretation of the quantum theory. An electron is in one orbit and then, through some indivisible action, appears instantaneously in another one. *If this interpretation of the quantum theory is a correct view of matter, nature in its submicroscopic dimensions operates in an indivisible and discontinuous fashion.* If this is so, then it cannot be maintained that local motion is gradual and successive nor that magnitude, no matter how small, is always continuous and divisible.[31]

To such an objection against a fundamental proposition of the present chapter, there are two answers: one from within specialized science, and the other from a general science of nature:

First, more recent language for describing the interior of the

[31] For an elementary presentation of the quantum theory, cf. B. Hoffman, *The Strange Story of the Quantum* (New York, 1961).

quantum atom speaks less of continuities and jumps and more of a kind of illocal presence of orbital electrons in atoms. In this manner of speaking, electrons are present inside atoms in the fashion not of simply located points but of "misty blurs," "charge clouds," "smears," etc.[32] Unlike the planetary system, where parts can be neatly identified, atoms are said to form wholes,[33] and there is no such reality as emptiness between the so-called parts. For the general theory of relativity, the fundamental reality in nature is not the discrete or particulate but the continuum or field. Thus, there is no clear-cut evidence for the existence in nature of the discontinuities alleged by earlier interpreters of quantum theory.

Meanwhile — and this introduces the second reply to our objection — there is evidence from carefully analyzed general experience, at a level of study where the mind is most at home and hence most sure of itself, that material things are continua. Even if specialized science, as in some interpretations of the quantum theory, should challenge this view, such theories must be held only as temporary dialectical models until a way is found for reconciling the settled knowledge, based on general experience, with the more difficult, obscure, and often highly tentative knowledge of the specialized sciences. It is not being proposed that such models be abandoned but only that they not be taken for reality. Though a working theory should not be given up until a better one can replace it, reservations should be made concerning the physical interpretation of the theory. Even within mathematical physics, according to the preceding paragraph, there is evidence against an interpretation of the specialized sciences which could find matter ultimately discontinuous. Meanwhile, there is the positive evidence for the continuity of matter when viewed at the general level which, unlike atoms and their parts, can be directly observed and directly analyzed.

Our analysis in this chapter has shown that continua, such as the mobile beings of our common experiences, cannot be resolved into indivisibles. A line is not composed of points, nor motion of moments, nor time of instants. All such divisible realities can always be divided into what is further divisible. The divisibility is potentially infinite, but an actual infinity of indivisible "parts" can never be a reality. This conclusion, though relevant in other ways, will receive a direct application in the next chapter.

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[32] F. Rice and E. Teller, *The Structure of Matter* (New York, 1961), p. 4.
[33] V. Weiskopf, in D. Lerner, *Quantity and Quality* (New York: 1961), pp. 53–69.

CHAPTER VIII
A FIRST AND UNMOVED MOVER

I. INTRODUCTION

The general science of nature deals with the universal causes or principles in the mobile world. If there were no separate treatment of material being in general and hence no distinct discussion of the general causes and principles of motion, it would be necessary to begin every study of a particular type of mobile being by first asking general questions, because these general questions are ones that logically occur prior to more specialized investigation. If the study of each particular kind of material thing would begin with the same questions concerning the causes of motion in general, there would be a useless repetition concerning the universal principles of motion, the definition of nature, the four causes, the character of motion in general, place, time, and the divisions of motion. In order to avoid useless repetition every time we examine a new kind of material being, there should be a separate treatment at the beginning of natural science concerning the universal principles and causes of mobile being. It is this treatment that we have called the general science of nature.[1]

There is one capital question within this general science which has not yet been asked and which, because of its extreme difficulty, is reserved to the end. *It is the question of the universal agent cause of mobile being, the question of the Prime Mover. What is the relation of motion to its movers? Is there a First and Unmoved Mover of the material world?* Just as we inquired about the universal intrinsic causes of mobile being and found them to be matter and form, so it is proper in a general science of nature to inquire about the universal efficient cause of motion.

[1] *Commentary on the Physics,* Bk. I, les. 1, n. 4.

II. SUMMARY OF OUR PROOF

a. Motion requires a mover

The most effective way of reaching the objective of our present chapter is first merely to explain the two principles in the proof for a Prime Mover and afterward to establish the proof by arguments for the two principles. Once the reality of a Prime Mover is shown, it will then be logical to ask about the attributes of such an Unmoved Mover insofar as they can be gleaned from material so far studied in our general science. For instance, is it proper to call a Prime Mover God?

Our first key proposition reads: *Whatever is moved is moved by something other than itself.*[2] *If a nail is driven into wood, it must be driven by a hammer; and if, in turn, the hammer is moved to drive the nail, the hammer must be moved by something else, say, the hand; and if the hand is moved, we have yet another cause, etc.* Hence, our proposition says that even a mover, if moved to act, must be moved by something other than itself. Nothing is properly self-moved. If *C* is moved there must be an extrinsic cause for the motion, say, *B;* and if *B* is moved in order to cause *C's* motion, it is moved by something other than *B*, i.e., there must be another extrinsic cause, *A*. And so on. In this way there may be a series of causes, one moving another toward the production of that effect which we have to explain. Our principle of causality states that whatever is moved is moved by something other than itself. There must be an extrinsic mover whenever there is motion. There is never any self-motion in the strictest sense of the word.

Motion is being taken for the present in a strict sense of a gradual, successive, and divisible process. If we looked to substantial change, it would become even more necessary to insist that whatever comes to be requires an extrinsic mover; for generation goes from non-being to being and if what is generated were self-generated, if it could bring itself into existence, it would have to exist before it existed, i.e., to exist as a cause and then to bring itself into existence, as an effect. This is clearly a contradiction.

But despite the evident need for an extrinsic cause in order to bring about generation of substances, our proof for a Prime Mover is going to rest on the analysis of motion in the obvious form of local motion.

[2] *Physics,* Bk. VII, ch. 1, 241b, 24–242a, 16; *Commentary on the Physics,* Bk. VII, les. 1 (whole lesson); *Summa contra Gentiles,* Bk. I, ch. 13. It should be remarked that St. Thomas repeats in this latter work the argument he has commented on from Aristotle's *Physics.* The English translation I have used for the principle of causality I owe to J. Owens, whose scholarly studies of the argument from motion are found in his, "The Conclusion of the *Prima Via,*" *The Modern Schoolman,* XXX (1952–53), 33–53; 109–121; 203–215.

This is the most manifest kind of change,[3] and even if there were no substantial changes in our world, local motion would furnish evidence that there is a Prime Mover.

In claiming that whatever is moved is moved by something other than itself, our meaning will be that nothing can move itself in a *primary* way, that is, as a *whole*. What is primary in anything is what essentially belongs to a thing when we take it as a whole as opposed to taking it according to its parts.[4] It is admitted that it is possible for a thing to move itself according to its parts. This is evident in the so-called self-motion attributed to living things; thus, the nervous system moves the muscles in the locomotion of a dog and the muscles move the limbs of the animal. In this light every living thing is characterized by a certain kind of self-motion, but it is self-motion where one part of the thing in question moves another part.[5] It is self-motion but not in a *primary* way. If the reality that was being moved were precisely the same reality that is doing the moving, then the motion would be self-motion in a primary way, and our argument shall show that this kind of self-motion is impossible. Whatever is in motion cannot be precisely the cause producing that motion. Whatever is being moved cannot be exactly the same thing as the mover of the motion in question. A whole cannot move itself as a whole. This must be established after we first explain the other principle in the argument for a Prime Mover.

b. The series of movers is not infinite

Our second proposition in proving that a Prime Mover exists states that in a series of movers where one moves another there is no actually infinite series, and so there must be a First Mover.[6] By way of elaborating on this proposition prior to proving it, it should be borne in mind that the series here in question is a series of essentially subordinated movers. In a series of movers only accidentally subordinated to one another, an actual infinity is possible.[7] A chicken comes from an egg, an egg from another chicken, and the other chicken from still another egg; there is no reason why such a series, stretching backward through the past, cannot be unending. In a series of this kind, the movers,

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[3] *Summa Theologiae,* I, q. 2, a. 3.

[4] *Summa contra Gentiles,* Bk. I, ch. 13; *supra,* p. 55.

[5] *Commentary on the Physics,* Bk. VIII, les. 10–11.

[6] *Physics,* Bk. VII, ch. 1, 242b, 34 ff.; *Commentary on the Physics,* Bk. VII, les. 2, (*passim*); *Summa Theologiae,* I, q. 2, a. 3; *Summa contra Gentiles,* Bk. I, ch. 13; *On Truth,* q. 5, a. 9.

[7] *On Truth,* q. 2, a. 10; *Summa contra Gentiles,* Bk. II, ch. 21; *Summa Theologiae,* I, q. 46, a. 2, reply 7.

operating not together but in succession, are accidentally subordinated to one another in the sense that a parent chicken need not be here and now influencing the hatching of an egg and may in fact even be dead. In movers essentially subordinated to each other, one mover is here and now influencing another, like the hand swinging a hammer, so that without the causality of the first there is no movement in the second.[8] In the driving of a nail, there is only an accidental subordination of the hammer's motion to the maker of the instrument, and in fact the maker may no longer be in existence when his tool is operating. But there is an essential subordination of the hammer to the hand that is here and now swinging it.

In summary, our concern at present is not whether in a series of movers accidentally related to each other there is an actual infinity but whether in a series of essentially subordinated movers there is an actually infinite chain of causes. *If there is no actual infinity in the series of causes here and now operating in such movements as the driving of a nail, the blowing of a leaf, or the evaporation of water, then the series of movers, being actually finite, must come to an end.* This means that there must be a First.

With the explanations of terms in our argument for a Prime Mover, the two crucial propositions of our proof remain to be established: whatever is moved is moved by something other than itself; and, in a series of essentially subordinated movers, there is no actual infinity.

III. WHATEVER IS MOVED IS MOVED BY SOMETHING OTHER THAN ITSELF

a. Hume's doubts concerning efficient causality

Experience reveals to us that mobile beings do not move themselves under their own power. Eggs do not lay themselves but require an animal of some kind as their cause. Paper will burn only when heat is applied to it from the outside. The wind blows off the branches of faded plants; they do not blow themselves.

Experience thus reveals that mobile being always requires a mover or agent. It reveals even further that when an agent stops acting upon an effect, the effect stops coming into being. A builder, for instance, is necessary to build a house; and when the builder stops building, the house stops being built. When the trees are shaking, we know that something is shaking them, and when the agent stops shaking the trees, the trees themselves stop being shaken and their motion ends.

[8] *Summa contra Gentiles,* Bk. II, ch. 38; *Commentary on the Physics,* Bk. VII, les. 2, n. 892.

Common experience, when analyzed, authorizes the induction that every motion requires a mover as surely as the convex side of a curve requires the concave. Whenever anything occurs in nature, the mind tends to ask: Who did it? or What did it? and it is confident that an answer can be found to such questions.

However, in the modern world it is strongly contested that there are efficient causes which actually exert an influence upon effects and bring something else into existence. The author who popularized this doubt regarding efficient causality is David Hume, although it was his contemporary, George Berkeley, who first proposed this idea. Today this view has an influence in the life of learning that it would be impossible to calculate. Let us see what it is.

Hume was a sensist. He claimed that there is no knowledge in man except sense knowledge and thus denied that man had the supersensory power of knowing that we call intelligence. Such a view of human knowledge would deny, of course, that causes can be known. For a cause is not a sense datum. It is not something like the colored or the sweet which our external senses can apprehend. Causality is not an appearance. It is not observable and hence not open to any direct measurement. Causality is not a thing but a *dependency* of one thing on another. In a more technical language, causality is not that which exists or operates (*principium quod*) but that by which something exists or operates (*principium quo*).

Hume held that we do not know causality in the sense of an influence, because he refused to recognize any knowledge in man except sense knowledge. He was at least consistent in this regard. For causality, being a dependency, can be understood only by an intelligence that transcends the senses. If the senses alone could get at causality as involving dependency, every animal would be a scientist seeking the causes of things. Hume's central conclusion was the denial of intelligence,[9] the power of man to grasp what things are and the power to recognize relations such as causality.

b. Hume's positive position

David Hume did more than deny our knowledge of efficient causes as real productive agents with a real influence over the effect. He proposed his own theory concerning our notions of causes. What we ordinarily call the cause-and-effect relationship, he claimed, is nothing more than regular sequences between things. He did not deny that

[9] *Enquiry Concerning Human Understanding;* cf. *Hume's Theory of Knowledge,* ed. D. Yalden-Thomson (Austin, 1953), p. 16.

there may be, in nature, genuine causal influences, but he affirmed that all we *know* about the existence of causes is regularities in temporal successions. He held that "we only learn by experience the frequent *conjunction* of objects, without ever being able to comprehend anything like *connexion* between them."[10] To interpret a Whiteheadean example[11] according to Hume's theory, it repeatedly happens, he would claim, that after light shines into human eyes, the eyes blink. Note that there is nothing observable here except a sequence of events in which one event, the blinking, repeatedly follows after another event, the flashing of light. After repeated sense experience of the sequence, light shining following by the blinking of eyes, we are led to conclude that given similar circumstances in the future *when* light shines into an eye, the eye will *afterwards* blink.[12]

All we observe, says Hume, is a regular temporal sequence; and when we call the first event an influence on the second, we are going beyond what facts warrant. In a kindred manner, it repeatedly happens that *after* rain falls in the springtime various plants start growing; and we are led to expect in future cases that after the rain falls the plants will grow. According to Hume, there would be no evidence in either the light-blinking sequence or in the rain-growth sequence that the first thing is an influence producing the second. All that we can observe, says Hume as quoted above, is the temporal sequence of *A* followed by *B*, "the frequent *conjunction* of objects, without ever being able to comprehend anything like *connexion* between them." *What we usually call causality is thus nothing but a temporal succession where one thing follows after another but is not, as far as our observation goes, actually influenced by that other thing. After this sequence goes on often enough, the mind associates the two members together and is led to expect that after the first thing occurs the second will follow.* It calls the first thing a necessary cause of the second. But in this, according to Hume, our minds are deceived, for there are no grounds to say that *A*, a so-called necessary cause, is anything more than a temporal antecedent of *B*, the so-called effect; there is no grounds to show that *B*, the so-called effect, is anything more than the temporal consequent of *A*, the so-called influencing cause.[13] Hume

[10] *Ibid.*, p. 71.

[11] A. Whitehead, *Process and Reality* (New York, 1929), pp. 265–266.

[12] In the pages cited in the previous note, Whitehead opposes Hume's view and claims that a man knows (because he feels) that the light made him blink. Whitehead is the notable exception to the generalization that Anglo-American philosophers of science, since Hume, have generally been Humean — except of course for neoscholastics.

[13] Hume's position will be found in the *Enquiry*, Sect. VII, *ed. cit.*, pp. 61–81.

really thought that for human knowledge causality as production or influence is an illusion. There is no evidence, he argued, that efficient causality is more than a temporal sequence. Let us listen to his own language:

> When we look about us toward external objects, and consider the operation of causes, we are never able, in a single instance, to discover any power or necessary connexion; any quality, which binds the effect to the cause, and renders the one an infallible consequence of the other. We only find that the one does actually, in fact, follow the other. The impulse of one billiard ball is attended with motion in the second. This is the whole that appears to the outward senses. The mind feels no sentiment or inward impression from this succession of objects: consequently, there is not, in any single particular instance of cause and effect, anything which can suggest the idea of power of necessary connexion.[14]

Hume thus changes the meaning of the agent cause from productive *influence* to regular temporal antecedent.

c. *Criticism of Hume*

Not all aspects of Hume's philosophy are of interest here. In fact, the central error of Hume, that all knowledge is sense knowledge, cannot be discussed in the general science of nature. Of interest at present is the question of whether efficient causality, insofar as we know anything about it, can be dismissed as ordered temporal sequence and nothing more.

The notion that efficient causality may be nothing but temporal succession runs directly counter to human experience. In pushing a sled up a hill, a boy is conscious that his effort is not merely a temporal antecedent of the movement of the sled but a real productive influence upon it. A carpenter, accidentally hitting his finger with a hammer, is sure to claim that the hammer is not merely a temporal antecedent of the injury but a real cause. Moreover, as Thomas Reid argued against Hume, there are many regular sequences not identified by us as causal ones, and if Hume were right in thinking that every regular sequence forced us to conclude by association that the first member of the sequence was the cause of the second, all regular successions in nature ought to be interpreted as causal ones. Night follows day, but we do not think of night as an effect of day and of day as the cause of night. In Bertrand Russell's figure, even though Chanticleer may crow every morning before dawn, no one thinks that he causes the daybreak to

[14] *Ibid.*, p. 64; concerning the reasoning behind Hume's requirement for the reality of cause, see J. Weisheipl, "Space and Gravitation," *The New Scholasticism*, XXIX (1955), pp. 176–177, n. 2.

occur. If the mind concluded by mere association that every temporal regularity was a causal sequence, these two examples would be taken as causal. But they are not. Our mind clearly distinguishes at least in some cases between repeated successions that are temporal only and those that are causal as well. Hume's claim, that all we know of causality is temporal sequence, goes contrary to human experience.

In addition to being against the verdict of experience, Hume's whole position concerning efficient causality runs counter to human reason. To say that a thing, for all we know, can be moved without requiring the influence of a mover is really to say that a thing may move itself. Now a thing that can move itself is, by definition, self-moved and hence spontaneous in its action. Uninfluenced in its behavior by outside causes, a self-moved mobile being could do anything at any time, any place, and any way. Uninfluenced, uncontrolled, self-moved, and spontaneous, our universe of material things would be disordered and chaotic. It would not be the cosmos that experience reveals but a chaos where nothing could truly be or be known. It is because things are ordered that we know they are not self-moved and not spontaneous. They are subject to control from the outside.[15] Not being self-moved, they must be moved by an agent distinct from them. This is the efficient cause.

C. E. M. Joad has forcefully pointed out what a disordered world there would be on the premise that there is no efficient causality:

> The implications of Hume's criticism of cause and effect are incompatible with the existence of the world assumed by common sense and affirmed by science. If, in other words, Hume's criticism of causation can be sustained, then no one thing can ever be said to be the cause of any other; we have no rational basis for calculation or for prediction, since both calculation and prediction assume that the same causes will in the future produce the same effects as they have done in the past, while, so far as anticipation is concerned, we have no ground for supposing that any action may not produce the most totally irrelevant and unanticipated results. There is no more reason to expect that the explosion of the gunpowder will follow the application of a lighted match than that it will follow the impact of a jet of water, no more reason to expect that the kettle will boil when it is put on fire than when it is placed on a block of ice.[16]

In a Humean world, anything could do anything.[17]

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[15] *Commentary on the Metaphysics,* Bk. 4, les. 1, n. 751.

[16] *Guide to Philosophy* (New York, 1936), pp. 220–221. For another telling refutation of Hume, see F. Meehan, "Professor Stace and the Principle of Causality," *The New Scholasticism,* XXIV (1950), 398–416.

[17] *Commentary on the Physics,* Bk. VIII, les. 7, n. 1027.

d. Summary of our notions of efficient causality

Important evidence can be adduced for the principle of causality: Whatever is moved is moved by something other than itself.

1. In replying to David Hume's analysis which turned efficient causality into a mere affair of temporal sequence, *it was shown that such a solution to the problem of causality would make the cosmos into a chaos.* Whatever could move itself could break into movement or variations of movement in any imaginable way, and the universe under such a condition would be a sheer spree of chance. Anything could do anything. Self-motion would engender a chance world, not the universe we experience. In contrast to this, the presence of order in our world indicates that things are not self-moved and hence freakish; this order indicates that things are moved only under the controlling influence of causes. A thing in nature cannot do anything whatsoever but is limited in what it does by the need of a mover outside of it.

2. *In a more positive way, the subject, form, and privation involved in all motion are each powerless to explain the fact that motion does occur.* They enable us to understand *what* motion is but not *that* it is in the real world. Privation, to begin with, cannot be an agent because it is non-being, and what is non-being cannot make or move anything. If the subject (matter) and the form cannot explain the motion which brings about the evolution of form from matter, then it is necessary to go outside the intrinsic principles of motion in order to find the mover which explains the motion. The subject of a motion, precisely insofar as it is a subject, is potential. Since the potential, as potential, cannot perform operations, the subject of motion as such cannot be the agent or mover for the motion. Form, the term of motion, is in existence only insofar as the motion is completed. As a principle that is actually present only to the extent that motion is over, the form attained cannot be an initiator of a motion. Since the intrinsic principles of a motion cannot be the mover required for the motion in question, it is necessary that there be a mover extrinsic to the motion, that is, extrinsic to the subject undergoing the motion and the form terminating motion. Whatever is moved is moved by something other than itself.

The argument here can be put in another form.[18] What is only capable of motion (the mobile as such) is in potency; but what is actually in motion is in act (imperfect act). A thing that moved itself as a whole would be wholly in act and wholly in potency to the modi-

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[18] Cf. *supra*, p. 101.

fication which motion brings about. A thing that in a primary way was heating itself to, say, a temperature, *T*, would be both potentially *T* as being heated and actually *T* as supplying the heat. In a similar way, the wet would be the dry, the heavy, the light, etc. In the case of a self-moved body, in the order of local change, a corresponding mixture of opposites would occur. A self-moved world would be one in which there were no differences,[19] like even the relatively up or down, because all polar opposites, like the hot and cold in our example above of heating, would be blended into a homogeneous and unintelligible mass.

3. From what has previously been proposed, another lead toward our principle of causality can be found in the relation of motion to action and passion.[20] Motion was seen to be the act of the potential insofar as it is potential, and insofar as motion is related to its subject in which it occurs, it was shown to be passion. But a patient requires an agent because the potential cannot be reduced to act except by something already in act.[21] *In other words, as characterizing a patient, motion requires an agent from which it comes.* There is as much need for an agent when there is motion as there is need for selling when there is buying or for an exterior angle of a figure when there is an interior one.

e. *Nothing moves itself in a primary way*

Our three approaches to efficient causality are intended to be *inductions,* prepared by dialectical preliminaries, that whatever is moved is moved by something other than itself. In approaching this principle motion will be taken only in its most obvious type as local motion; and again, in order to clarify what we intend to do, we propose that (at least at the level of local change) there is no self-motion in a *primary* way. Whatever would locally move itself in a primary way and hence would not depend, for motion, on something other than itself would be an impossibility. Let us turn to the physical proof of this proposition.[22]

Anything that moves itself primarily would not come to rest whenever some part of itself, i.e., the cause, came to rest. Putting this in a more positive vein, let us propose that whatever comes to rest

[19] *Physics,* Bk. VIII, ch. 5, 257b, 2–27; *Commentary on the Physics,* Bk. VIII, les. 1052–1053.

[20] Cf. *supra,* p. 102 ff.

[21] *Commentary on the Physics,* Bk. III, les. 5, n. 324.

[22] The status of a proof as being for example, physical or metaphysical, is determined ultimately by the character of the middle term; cf. *Exposition of the Posterior Analytics,* Bk. I, les. 39. Cf. the syllogism *infra,* p. 154.

whenever part of itself comes to rest is moved by that very part.[23] For *X*, a whole, to come to rest whenever *Y*, a part, comes to rest is a sign that *Y* is a mover of *X*. If *Y* comes to rest but *X* keeps on moving, there is evidence that *Y* is not a mover of *X*. If the hand of a walking person comes to rest in the sense of stopping its swinging motion but at the same time the legs continue to move in local motion, it can obviously be argued that the motion of the hands is not causing the walking motion of the man.

All of these judgments can be clarified if we apply them to an example:[24] Let *AB* be a body in motion, and let us suppose *AB* to be self-moved in a primary way. As was shown in the previous chapter, whatever is locally moved is divisible. Hence, since there is no incongruity in actually dividing what is divisible, let the mobile and hence divisible body *AB* be divided at *C* into *AC* and *BC*. Suppose that when part *BC* comes to rest, the whole *AB* comes to rest. In this case it can be concluded that the whole *AB* is moved by reason of a part, namely *BC*. Since the whole is moved by a part, it is not self-moved in a primary way. If the whole were moving a whole, it would not come to rest upon the coming to rest of a part. If it be counter-argued that after division *AB* is no longer the same whole, the objection proves our point: we have controlled it by controlling a part. Its whole (primary) character as a locally moving body is thus dependent on that quiescent part and thus caused by that part.

If *BC*, a part of *AB*, is made to come to rest but the whole *AB* keeps on moving, then the whole *AB* is moved while the part *BC* is at rest and the motion of the whole is dependent on the motion of the other part, *AC*. Since the motion of the whole, *AB*, is dependent on the motion of the part, *AC*, the whole is not moving the whole, and hence *AB* is not self-moved in a primary way.

If the part *BC* comes to rest and the whole *AB* either comes to rest, as in our first assumption, or continues to move, as in our second one, no matter which of the alternatives is true, our point is proved: *AB* is not self-moved in a primary way. If *BC* comes to rest and *AB* also does, it can be argued that whatever comes to rest whenever part of itself comes to rest is moved by that very part. *AB* is thus moved by *BC* on such an assumption. If it is assumed that *BC* comes to rest and *AB* continues to move, the motion of *AB* is due to the remaining

[23] *Physics*, Bk. VII, ch. 1, 242a, 16 ff.; *Commentary on the Physics*, Bk. VII, les. 1, n. 886; *Summa contra Gentiles*, Bk. I, ch. 13; *Commentary on On Generation and Corruption*, Bk. II, les. 10.

[24] *Physics*, Bk. VII, ch. 1, 242a, 20–242b, 20; *Commentary on the Physics*, Bk. VII, les. 1, n. 886.

part, *AC*. In neither case does *AB* the whole move *AB* the whole.[25] It may be worth repeating, and answering, a possible objection to this proof. Once we tamper with *AB* by, say, stopping a part of it, we no longer have the same locally moving whole. But the answer is that by changing a part we have changed the whole, and the whole, far from being moved in a primary way, is thus dependent on its parts. Dependence is what we mean here by causality.

It would be easier to show that generation, the change from non-being to being, requires a mover. But the foregoing proof takes motion in its first meaning as a continuous process of local change, and it is shown that even at this level an agent is always required. "No continuous being (continuum)" can move itself primarily.[26] Nothing in local motion moves itself as a whole. Nothing in local motion moves itself in a primary way. Every local change, being divisible, i.e., material, requires a mover.[27] This was to be our first step in showing the existence of a Prime Mover.

The proof here is the demonstration of the need for an agent cause from the character of the material cause, and it is a causal (*propter quid*) demonstration that is physical, rather than metaphysical.[28] For the middle term, *the divisible,* is taken from the very nature of the mobile, as was shown previously. Divisibility belongs only to material or physical things, not to all being, e.g., not to spiritual things. Here is the formal syllogism:

Nothing divisible is a thing that moves itself in a primary way, i.e., as a whole.
Every body (mobile being) is divisible.
Therefore, no body (mobile being) is a thing that moves itself in a primary way, i.e., as a whole.

f. Objection: The law of inertia

An introductory work of this sort is hardly the place to treat technical objections against any of our basic propositions. Nevertheless, there

[25] The foregoing reason may be compared to the methods of induction in the British empirical philosophers, methods that require more than sensism in order that they be adapted here. Cf. J. S. Mill, *System of Logic,* Bk. III, ch. viii (New York, 1930), pp. 255–263.

[26] *Commentary on the Physics,* Bk. VIII, les. 7, n. 1028.

[27] *Summa contra Gentiles,* Bk. I, ch. 13; *Commentary on the Physics,* Bk. VII, les. 1, 889.

[28] For the difference between these two kinds of demonstration in a science, cf. *supra,* pp. 2–3. St. Thomas terms this demonstration a causal one, in opposition to the Arabian philosopher, Averroës. *Commentary on the Physics,* Bk. VII, les. 1, n. 889. The syllogism demonstrates the need for an agent cause from the nature of the material cause.

is at least one common difficulty that must be mentioned, as it arises out of science in the modern sense. The difficulty is the law of inertia which is the first law of Newtonian physics.[29] According to this well-known law or axiom, a mover is necessary in order to start a body in motion or to increase or decrease the velocity of a moving body; but once in motion, the axiom says, a body will continue to move at the same uniform rate without the need of an external agent. Newtonian physics would seem to authorize the view that motion at a constant velocity does not require an extrinsic mover but that a mover is required only where there is acceleration.[30]

According to the position we have outlined above, a mover is needed not merely to initiate a motion or to change the velocity of a moving body. Indeed, a mover is necessary wherever there is motion and for as long as the motion endures. Assume a body moving along a straight line *XY* and having "arrived" at some intermediate "point," *C*. On this supposition, it would be proper to say that the body had completed the *XC* part of its trajectory but has yet to accomplish the *CY* portion of its movement. Now having "arrived" at *C*, the body is potential to cover the distance *CY*—indeed just as potential to go through *CY* as it was potential, prior to the motion, to go through the whole *XY* and/or to complete *XC*. Since the body at *C* is only potential to cover the distance *CY*, it needs a mover to move it through the distance in question; it cannot move itself through *CY* in a primary way because it can be subjected to the same analysis as our body *AB* which we considered to be already in motion like an inertially moving body going from *C* to *Y*. A body needs a mover not only to start it moving but to keep it moving as long as the motion goes on. *Our foregoing analysis*[31] *was made in the light of the assumption that a body is actually moving, and we asked whether the motion could account for itself.*

The mathematical physicist ignores the agent cause by the very nature of his science. But to search for such a cause in motion can still be the task of another and strictly physical approach to nature.

It may not be possible to name the mover of a body moving at a constant velocity and approximating the mathematics of Newton's axioms. There are several theories[32] in the history of science con-

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29 *Mathematical Principles of Natural Philosophy, ed. cit.*, p. 13.
30 Cf. for instance, E. Whittaker, *Space and Spirit* (Chicago, 1948), pp. 50–51.
31 Cf. *supra*, pp. 152–154.
32 For two theories in St. Thomas, see *Commentary on On the Heavens*, Bk. II, les. 8; *On the Power of God*, q. 3, a. 11, reply 5.

cerning the causes that keep a body, e.g., a projectile, in motion after its initial push or pull. Our proof for an extrinsic agent in all motion is a general one which does not require us to know in any exact way the particular agents in this or that type of motion, but assures us that such an agent must always exist if local motion exists. Our proof rests on the nature of local motion itself. As divisible, such motion does not have a primary character, and so a projectile or a bullet or any other body moving even at a constant velocity from *X* to *Y* would require a mover to keep it going. For a mover is necessary to start it from *X* because there is nothing primary in the motion of the body that could make it move itself from *X;* having arrived at some intermediate point *C,* the body even at a constant velocity cannot move itself from *C* because there is nothing primary that could make it move itself from *C*. The same logic could be applied through all intervals of distance between *X* and *Y*, and our conclusion remains that projectiles, even after leaving their projectors, still require extrinsic agents throughout all moments of their motions.

To find the causes operating on a projectile is a different question from asking whether there are causes to begin with. To find such causes involves knowledge more distinct and particular than the general knowledge: whatever is moved, is moved by something other than itself. It is possible to answer our general question, whether all motion requires a cause, without knowing the answers to more particular questions concerning the precise causes of particular kinds of motion.

IV. THERE IS NO ACTUALLY INFINITE SERIES OF MOVERS

Our second proposition central to the proof for a Prime Mover is: In a series of movers, essentially subordinated to each other, there is no actual infinity.[33] If, as our proposition reads, the series of movers is finite, there must therefore be a First Mover. It now remains to prove that in essentially subordinated movers there is no actually infinite series.

a. An infinite series would occupy infinite space and yet be in a finite time

Let us lay down again an example of an essentially subordinated series of movers. Take the case of a hand moving a stick that in

[33] *Physics,* Bk. VII, ch. 1, 242b, 19 ff.; *Commentary on the Physics,* Bk. VII, les. 2 (*passim*); *Summa contra Gentiles,* Bk. I, ch. 13; *On Truth,* q. 5, a. 9.

turn moves a stone along the ground.[34] The hand is a prime mover among the members mentioned, the stick is a moved mover, and the stone is merely moved. In more general terms, *A* moves *B*, and *B*, though moved, also moves *C*, and *C* is merely moved. It is, of course, possible to have many more members of a series of motions and movers. But our argument says that the series of essentially subordinated movers, as in the case just illustrated, is finite no matter how long the series, and that therefore there is a First Mover.

The moved effect and the mover, in any motion, are simultaneous. The hand moves the stick, and as soon as the hand stops moving it, the stick stops being moved. When a builder stops building a house, the house stops being built. *A* moves *B*, and as soon as *A* stops moving, *B* ceases to be moved. If *B* in turn moves *C*, then as soon as *B* stops being moved by *A*, *C* stops being moved by *B*. In a series of movers, however long, all of the members must be operating in some kind of simultaneity. Moreover, as strictly physical and hence quantified, our series of natural causes must be stretched out so that one is outside the other — like the stick that is touched by the hand and in turn touches a stone. Physical causes are thus in quantitative contact or contiguity with each other.[35] In terms of another example, the carpenter touches the hammer that touches a nail that in turn touches the wood. Whatever is quantified, like physical causes, is hemmed into itself and cannot influence other things without contacting them directly or through a quantitative medium. Position or absolute "hereness" is in the very nature of geometrical quantity. For instance, a point is characterized by its position, and is only in imagination moved elsewhere. Elsewhere, it is a different point. So with a line, plane, or solid. Two geometrical solids of equal dimensions differ only in their position. Thus what is quantitative is radically hemmed in to a given space, and action among quantitative beings, thus spatially limited in themselves, must always be by continuity (as in the parts of an organism) or contiguity (as in the case of the hammer, nail, and wood).

Now if we are going to allow an infinite series of essentially subordinated physical, and therefore quantitative, movers, they will stretch out into an infinite space, and since they are all at least in contact or contiguity, we can consider them collectively as forming

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[34] *Summa contra Gentiles*, Bk. II, ch. 21; *Commentary on the Physics*, Bk. VII, les. 2, n. 892.

[35] *Physics*, Bk. VII, ch. 1, 242b, 27; Bk. VII, ch. 2 (*passim*); *Commentary on the Physics*, Bk. VII, les. 3 (*passim*); *Summa contra Gentiles*, Bk. I, ch. 13.

one infinite body just to simplify the analysis.[36] But this infinite, and therefore immeasurable, "body" undergoing motion moves in a finite, measuring time. For things are done and over in our world; things are made and moved in definite, hence finite times. But such an observed motion, which is completed and measured by a finite time, cannot be the motion of our assumed infinite "body," whose motion must itself be infinite and hence immeasurable. An infinite motion could not be measured by time; the completed motions we observe are so measured.[37] Thus the infinite character of our assumed body must be denied; the string of movers forming such an assumed body must be finite. If the series of movers is thus closed, because finite, there must be a First Mover.

b. No motion without a first mover

Another and "more certain way"[38] to reach our conclusion that in a series of essentially subordinated movers there must be a First is to raise the question of why we must reach *B* to explain *C's* motion and if *B* is moved in its own turn, why we must go to *A* to explain *B's* motions. The answer is an easy one, but it is enlightening. We need *B* to explain *C's* motion because *C* is unable to explain it, and we must go to *A* when *B*, as a mover, is unable to explain that it (*B*) is being moved in turn. In short, not finding in *C* a reason for *C's* motion, we go to *B*, and not discovering in *B* an explanation for *B's* being the cause of *C's* movement, we come to *A*. And so on.

We are seeking to explain *C's* motion which is itself not capable of explaining that motion. Nor is *B* so capable because it requires *A*. If *A* in turn is not able to explain motion we must go even beyond it. But if a series of this sort is infinite, the incapability of explaining motion is multiplied to infinity. *In our quest to explain motion, we meet, on the hypothesis of an infinite series of movers, an infinite series of non-explanations of what we are trying to explain; in seeking the reasons why a motion should occur, we give an infinite multitude of reasons why it should not occur.*

But we cannot explain why motion occurs by positing an infinite multitude of reasons why it should not occur. It is no explanation of motion merely to extrapolate to infinity non-explanations of mo-

[36] *Physics,* Bk. VII, ch. 7, 242b, 24–29; *Commentary on the Physics,* Bk. VII, les. 2, n. 894.

[37] *Physics,* Bk. VII, ch. 1, 242b, 29–243a–3; *Commentary on the Physics,* Bk. VII, les. 2, n. 894.

[38] *Commentary on the Physics,* Bk. VIII, les. 9, n. 1040.

tion. If there is such an actually infinite series of essentially subordinated movers in any motion, such a series, far from accounting for motion, would be infinitely stacked against motion. So if motion occurs, the series of essentially subordinated movers in question must be finite, and if it is finite, then there is a First or Prime Mover.

In regard to our second principle for proving the existence of a Prime Mover, the argument is once again physical. It is based on motion and the requirements for explaining motion.

c. A summary

According to the first part of our argument for a First Mover, which established the need for an agent cause in all motion, whatever would not be moved by an agent cause would not be moved at all, and there would be no motion. According to the second part of our argument, a series, if infinite, of essentially subordinated movers would provide infinite and hence complete grounds why motion should not be. *If, as experience attests, motion does take place, there is a mover for it because of the principle of efficient causality; and there is a Prime Mover because the series of essentially subordinated movers cannot be infinite.* The complete argument for a Prime Mover is a factual (*quia*) demonstration. The Prime Mover is not the subject of physical knowledge but is shown to exist from an analysis of that subject, namely mobile being.

V. POSSIBILITY OF AN ETERNAL WORLD

a. Two alternatives for reason

Our proof for a Prime Mover does not require that the universe be finite in duration.[39] That the world began in time we could not know by reason alone. For all the unaided reason can conclude, the world may have been temporally infinite.

In metaphysics it is proved that the world was created, i.e., was produced without a preexisting subject.[40] From the side of the Maker of the world, God had the power to create it from all eternity, and so from all eternity He could have produced it. From the side of things made, there is no reason why any one creature should have been the first and why some other creature could not have been created before it, and why still another creature could not have pre-

[39] *Ibid.*, Bk. VIII, les. 1–5 (*passim*); *On the Eternity of the World, passim; On the Power of God,* q. 3, a. 14, reply 8; *Summa Theologiae,* I, q. 46, a. 1; *Summa contra Gentiles,* Bk. II, chs. 33–38.

[40] *Summa Theologiae,* I, q. 44, a. 1.

ceded, and so on and on. There is no creature whose nature requires that it be the first thing created; creatures, from their side, could have been produced without any one's being first. But even if the world had been created from eternity, it would still have been dependent from eternity on God. Even if it had no temporal beginning, it always had or has a causal beginning.[41]

Did the world have a temporal beginning or did it exist from all eternity? Reason alone cannot say. The question is an open one for reason and is settled only by supernatural revelation. Physical science, as the term is being understood here, is not even concerned with the creation of the world. It is only concerned with the movements and changes of things that already are.

b. The hypothesis of an eternal world

If reason assumes the alternative that the world had a temporal beginning, it is easy to show that there must be a Prime Mover. "Everything new," as St. Thomas says, "requires an innovating principle."[42] *Ex nihilo nihil fit.*

If reason assumes the other alternative that the world had no temporal beginning, it requires a more complex argument to show the need for a Prime Mover. *But if it can be shown that even on supposition of an eternal world a Prime Mover would be necessary, it would be even more compelling to say that a Prime Mover is necessary for a universe temporally finite in origin.* Our proof allows for an eternal world, and if its proof is valid on such an assumption, it would be even stronger on the assumption of a world that began in time.

In our analysis, a Prime Mover is reached as a Mover operating here and now as the First Mover of the nail or the stone or of a blowing leaf. Here and now there is motion, and here and now without a Prime Mover such motion could not be. The moment the hand stops driving a nail, the nail stops being driven, and if it is argued that the nail, after being hit, continues slightly through the wood, by the law of inertia, recourse must be had to our previous derivation of the principle of causality.

VI. ATTRIBUTES OF THE PRIME MOVER

a. The relevance of this question

Our conclusion to the existence of a Prime Mover has rested on two propositions: Whatever is moved is moved by something other

[41] *On the Power of God,* q. 3, a. 14.

[42] *Commentary on the Physics,* Bk. VIII, les. 1, n. 970.

than itself; and in a series of essentially subordinated movers, there is no regression into actual infinity.

There are grounds to question just how much can be known about a Prime Mover within the limits of a natural science. The problem of a Prime Mover belongs to the science of nature because the aim of our science is to explain mobile being; to achieve this explanation, it is necessary to admit the existence of a Prime Mover.[43] But can we conclude that our Prime Mover is really what in the Judaeo-Christian tradition we call God? Is there only one such Mover? Is such a Mover eternal, simple, personal, provident, the creator of all things outside of Him? *A physical approach cannot answer all of these questions and even questions which it can answer are answered better in metaphysics or natural theology.*[44] A physical science, even if it did no more than prove the existence of a non-physical cause which we have called a Prime Mover, would be doing the greatest service it can perform for human reason. It would relate our material world to what is not material and whose very existence is much more valuable to know that the essences of all material things. Actually the physical approach to a First Mover can say very little about such a Mover. How can such an approach prove that there is only one Mover that is non-physical? Metaphysics can show that there is only one Supreme Being. But, there is no warrant, on the basis of purely physical evidence, to identify a Prime Mover with the God of Judaeo-Christian revelation. Our language in this book has deliberately referred only to *a* Prime Mover, because purely physical knowledge can provide no basis for switching from the indefinite article to the definite one.

But at least two attributes can be predicated of a First Mover by way of denial of the mobility and materiality characteristic of physical beings. A Prime Mover must be immobile, hence non-physical and immaterial, hence spiritual.

b. Immobility and immateriality

If a Prime Mover were mobile, then such a Mover would be open

[43] *Commentary on On the Trinity of Boethius,* q. 5, a. 4, English translation by A. Maurer, *The Division and Methods of the Sciences* (Toronto, 1953).

[44] *Summa contra Gentiles,* Bk. I, ch. 13; *Commentary on On Generation and Corruption,* Bk. I, les. 7. When in this note and those following metaphysical works, like the *Commentary on the Metaphysics,* or theological works, like the two *Summae,* are cited, the reader should bear in mind that we are lifting statements out of context. The *Metaphysics* and St. Thomas' *Commentary* should be read as metaphysics, and the two *Summae,* from beginning to end, are formally theological. *Materially* they contain philosophy and philosophy relevant to this chapter. That is why such works can be cited here and below.

to being moved through some other mover. But this position cannot be maintained.

A Prime Mover that was mobile, and hence dependent on another Mover for its actualization, would not be First. If it were mobile, it would be like any other mobile being, moved by something other than itself, and in our search through a closed, finite series of essentially subordinated causes, we would not yet have come upon a First Mover. *Such a Mover cannot point beyond itself in the sense in which a mobile being must be referred to something other than itself for the cause of its motion.* A Prime Mover must therefore be immobile,[45] hence not physical.

A Prime Mover must also be immaterial, because indivisible. If it were divisible, it would be dependent on its parts, hence not First again. Because a Prime Mover lacks parts,[46] it is nonquantified or spiritual. Material substances, of course, are not quantity, but they depend on quantity, and they can be destroyed by taking them apart. But a Prime Mover has no such dependence. It is Prime or First. *A Prime Mover is therefore spiritual, and once again, our discovery that such a Mover exists puts us beyond the material world.*

Such a Mover can move without being moved because action, i.e., causing motion, is *from* an agent; being moved on the other hand is a change *in* the patient.[47] Action does not imply receiving. Unlike motion, to be a mover does not necessarily imply being moved.

VII. TOWARD METAPHYSICS AND TOWARD MODERN SCIENCE

a. Being and mobile being are separated

The proof for a Prime Mover opens the door to another realm of being and another realm of human science, namely metaphysics. Previously, for all that unaided reason could know, mobile or material being is all the being that there is; previously, there is no reason to posit any kind of being except physical being.[48] Now, in the proof for a Prime Mover, reason discovers that being is not necessarily

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[45] *Physics,* Bk. VIII, ch. 9, 266a, 9; *Commentary on the Physics,* Bk. VIII, les. 13 (*passim*); cf. also, *Summa Theologiae.*

[46] *Physics,* Bk. VIII, ch. 10 (*passim*); *Commentary on the Physics,* Bk. VIII, ch. 23 (*passim*); *Summa Theologiae,* I, q. 3 (*passim*); *Summa contra Gentiles,* Bk. I, chs. 17, 18, 20.

[47] Cf. *supra,* p. 102.

[48] *Commentary on the Metaphysics,* Bk. III, les. 6, n. 398; Bk. VI, les. 1, n. 1170; Bk. XI, les. 7, n. 2267.

mobile[49] (physical) and divisible (material); *for there is a being, according to our proof, which is immobile (non-physical) and indivisible (immaterial)*. It is now seen that the name *being* is applicable to at least two levels, the mobile or material and the immobile or immaterial. Being does not depend on motion and on matter in order to be and to be understood. A science called metaphysics now becomes possible. Its subject is neither material nor even immaterial being but being as being.[50] But we do not discover that there is such a subject without our proof that there is an immaterial and immobile world and without proof that mobile being, hitherto taken by reason as the only reality, is not truly unique. Our proof for a Prime Mover is therefore a precondition of metaphysics. Without such a proof, although we could conceive of being that did not require motion and matter in order to be and to be understood, we would not know that being was *really* distinct from mobile being and hence was really capable of founding an autonomous science. While the science of nature and metaphysics remain distinct disciplines, metaphysics presupposes the science of nature as a material condition.[51] There is thus one more basic type of theoretical science besides the physical and mathematical. This is metaphysics, the science of being as being.[52]

A Prime Mover, because it is immobile and indivisible, is not strictly a physical cause. Nevertheless, it falls within the scope of natural science because it is necessary in order to explain motion. Let us listen to the words of St. Thomas Aquinas on this point:[53]

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[49] Such a negative judgment is termed by St. Thomas a "separation"; *Commentary on On the Trinity of Boethius*, q. 5, a. 4, *transl. cit.*

[50] *Commentary on the Metaphysics*, Bk. IV, les. 1, n. 529–531.

[51] J. Maritain, *The Philosophy of Nature*, transl. I. Byrne (New York, 1951), pp. 122–123.

[52] For the division of the sciences, see *Commentary on On the Trinity of Boethius*, q. 5, *transl. cit.; Summa Theologiae*, I, q. 85, a. 1, reply 2; *Commentary on the Physics*, Bk. I, les. 1, n. 2. Missing from this list is mathematical physics, which though a hybrid and not a basic science according to our division enjoys today a position of historical and cultural importance perhaps never before realized by any purely secular discipline. For its nature see my *Science and Philosophy* (Milwaukee, 1965), ch. VII.

[53] *Commentary on On the Trinity of Boethius*, q. 5, a. 4. Fr. G. Klubertanz thinks that "an immaterial, immobile being" cannot be demonstrated short of metaphysics itself because all predicates in the philosophy of nature must involve materiality and mobility and to claim that a Prime Mover exists is to assert that he "is sensible, material and changeable." *The Philosophy of Being* (New York, 1955), p. 43.

Our contention is that a Prime Mover is not the subject of physical knowledge but a principle of the subject — the universal agent cause of motion; a science has a right to seek its principles to show that they are but not necessarily what they are. Moreover, what makes a proof physical is not the predicate of the demonstration but ultimately the middle term employed.

> Natural science does not treat of the First Mover as of its subject or as part of its subject, but as the end to which natural science leads. Now the end does not belong to the nature of the thing of which it is the end, but it has a relation to it; as the end of a line is not the line but is related to it. So also the First Mover is of a different nature from natural things, but it is related to them because it moves them. So it falls under the consideration of natural science, not in itself, but in so far as it is a mover.

b. Context for modern science

Proof for a Prime Mover is thus a limit or term of our science, "the end to which natural science leads." Every important conclusion developed in the foregoing chapters has gone into our proof, and "the end to which natural science leads" has opened a whole new scientific horizon to our gaze. But the mind, following the order of learning proper to reason itself, is not yet ready to enter upon the difficult territory of metaphysics. After a general science of nature, there must be a penetration of the particular kinds of material being to continue that same science of nature which begins with a study of mobile being in general. In descending to a more detailed knowledge of matter and form, of agent and end, of motion, time, place, and other realities considered in the foregoing pages, natural science in its more sophisticated form can *logically* begin. Of course modern science as practiced does begin without explicit reference to what we have been calling a general natural science. But leaving aside the problem of a Prime Mover which has a unique status because it leads us beyond the physical world, the modern natural scientist must inevitably make an implicit and unanalyzed commitment on such issues as fundamental versus superficial change, the principles of motion, the nature of nature, chance, motion, time, place, continuity, and the problem of the agent cause. And he responds to these issues before he starts his specialized work, if it be true that generic notions of nature have, with respect to more specialized notions, a priority that is logical and pedagogical, though not necessarily involving a time lag between the two levels. Thus, in claiming that specific science of nature can only begin after the more general science, the emphasis is being put upon a *logical* beginning, not the haphazard beginning knowledges may have in the *historical* order. The modern natural scientist is thus being invited to go back and "think through" into conscious form his unanalyzed presuppositions from a more general natural science. This would be a step toward an integral physical science — complete in the sense of going back to starting-points.

A proposal of this kind implies that there is more than a forced relationship between science as conceived by the Greeks and science in its modern drive and dress. But if there is a similarity, there are differences too. Unlike Aristotle, the modern scientist does not consciously start with general principles like those treated in the *Physics* and that assure the certitude of scientific knowledge. As another difference between the two concepts of science, the modern student of nature usually does not pursue all of the four causes. Mathematical physics must in principle ignore both the end and the agent. Thus the relation between modern sciences of matter and a philosophy of nature is not simple. Both specialized natural science and mathematical physics relate in different ways to a more general science which, we are claiming, can provide the initial stages, the broad outline, for working toward a synthetic view of our world to which all studies of matter should, in principle, contribute.

Our preceding discussion of the relation between generic and specific sciences of nature left aside the meaning of the proof for a First Mover. The problem of a Prime Mover, we have said, is unique as physical knowledge because it takes us to the limit of such knowledge, as the point is the limit of a line. But now l us ask what difference, in the work of the specialized scientist, wou a proof for such a Mover make? As in other parts of natural science such a proof would make no difference in the content of specialized science. It would not even provide a means of physically interpreting the results of science, because a Prime Mover is not a physical reality.

But to the modern scientist who, in his own specialization, does not raise the more generic question of the universal agent cause, his subject would mean more were it known that a nonphysical, spiritual Mover were moving the things he studies. That such a Mover were known to be operating in the subject-matter of a scientist would lend a new dignity to that subject-matter,[54] without asking the scientist to stop his specialized work and enter into metaphysics. For a proof for a Prime Mover who lies *beyond* the physical should never be an excuse to give up the quest for rationality *within* the physical; the eminence *of* a subject must never take the place of a "tough-minded" search for reasons *within* the subject. But dignity, while not adding anything extrinsically to a science by way of content, can surely make that science intrinsically more worthy of pursuit.

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[54] *Commentary on On Meteorology*, Bk. IV, les. 1.

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