The Body of Science
and
The Science of Bodies

By
George A. Blair

Ndala

Ndala
4049 Victory Parkway
Cincinnati, Ohio 45229

CONTENTS

INTRODUCTION

0.1. The subject-matter

Basically, what this book is about, as the title implies, is a study of what it is to be a body, with all the characteristics bodies have as such.

It is not quite so simple, of course. Since what today are called the "physical sciences" study bodies, and since especially physics and chemistry make as their study bodies in what might be called their "bodiliness" (as opposed to biology, which studies bodies as living), we are going to have to do several things to make this study worth while.

In the first place, we will have to justify what we are doing as scientific, if it is different from physics and chemistry, and they are sciences. Secondly, we will have to show that it is different from physics and chemistry, and not only something that neither of these sciences treat, but something that they cannot treat. Thirdly, we will have to relate our conclusions to those of physics and chemistry, and show how what we have discovered supplements what is known from physics and chemistry.

0.2. The approach

Since there is a (somewhat justified, given the historical situation) prejudice against philosophy as scientific, the first task we face is to investigate what science is doing, and why it manages to advance. Hence, the first part of the book is not going to be about bodies at all, but about scientific method: what it is, why it works, why it apparently deals only with what is observable, but actually goes beyond observations, and why it is justified in doing so.

We are not going to do a historical survey of what is called "philosophy of science," which has, in this century, undergone several drastic changes, because of problems which, I think, stem from its taking the Kantian notion of "cause" as "the" notion of cause and rejecting it, and thus trying to explain science without resorting to causes. I contend that this is bound not to succeed, because science deals precisely with effects and causes—though not in the Kantian sense of the term. "Effect" and "cause" must be carefully defined. Once this is done, a coherent theory of why scientific method works can be developed. What we are going to do is try to develop this theory, and only refer in passing to other theories which differ from it.

At any rate, what we are first going to do is try to make out a case that a proper definition of "effect" and "cause" can make sense out of what scientists are doing; and then generalize the scientific method so that we can do philosophy with a version of it, and have some hope that what we are doing will be scientific and not mere speculation.

In this first part, then, we will discuss the starting-point of scientific investigation, and the five traditional "steps" of scientific method: observation, hypothesis, experiment, theory, and verification. We will see why science uses operational definitions, why scientists tend to measure things, and why mathematics, especially probability and statistics work as scientific tools, why theories are supposed to be simple, logical, and comprehensive, why they almost universally predict something, why models are useful in theories, and why "verification" is really "falsification." This theory of science will then predict that a science like philosophy ought to exist if it is true; and we will show that the prediction is verified and develop our philosophical method.

We will then be able to enter into our philosophical investigation of bodies; and I am going to divide up the investigation into two parts, taking my cue from physics; the first will be what I call "philosophical statics," the second, "philosophical dynamics."

Philosophical statics describes the constitution of a body as such ignoring changes which may happen to it; if you will, it will be a description of *what* changes, rather than *what it is doing* as changing. In this section, we will try to see what energy is, and show why the philosophical definition of energy is what is being referred to by the different definition in physics. We will try to show what it is about energy that allows it to be measured, what its relation is to force and work, and why mass is to be considered a form of energy. We will look at those strange forms of energy called fields, and see how they account for what we think of as distance, position, and space; and while we are about this, we will be able to solve a problem that has been plaguing physicists for the past thirty years or so.

In the second part of philosophical statics, we will try to describe, not single forms of energy, but units of many forms of energy. This will allow us to see what "matter" is, and what bodies actually are; and while we are about this, we will see a basis for the conservation of matter, and why it is the conservation of mass-energy.

In entering philosophical dynamics, we will first discuss what is involved in any change, and the bodily conditions that make change possible. We will then be able to define the two basic kinds of change (those dealt with in physics and chemistry), and show what the conservation of energy has to do with changes in bodies. Then we will concentrate on the act of changing itself, and consider process and especially movement, showing how Newton's laws apply. We will see that every process has a purpose, and how process is related to direction and velocity, as well as why velocity is a "vector quantity" rather than a "scalar." Process, we will discover, has two quantities, length-of-process and velocity; and it is the relation of these two which is the basis for time.

0.2. The approach

Once time is introduced, we may discuss the relativity of time, and try to arrive at some notion of momentum and acceleration. This will lead us deep into problems connected with Einstein's General Theory of Relativity and quantum mechanics. Our own approach will allow us to make a prediction that it might be possible, by taking an entirely different focus on physical bodies (the one implied by this philosophical theory) to develop a physics that combines classical, relativistic, and quantum physics into a consistent single approach.

We will finish philosophical dynamics by making another prediction, about the nature of evolution.

0.2. The approach

PART ONE

SCIENCE

CHAPTER 1

THE SCIENTIST'S STARTING-POINT

1.1. Why not just ask a scientist?

It would seem to be a simple thing to find out what science is all about: ask a scientist. Scientists presumably know what they are doing; and they are probably willing to talk about it.

Unfortunately, though it's certainly true that scientists are generally willing to talk about what they are doing, and while it's also true that they know what they are doing in a sense, it isn't necessarily the case that they know what they are doing in the relevant sense. A physicist, for instance, is very adept at handling the equations in his science, and even developing mathematical ways of describing things he sees in the laboratory; but *why it is* that this particular procedure produces results, while others don't, is not part of his knowledge as a physicist. Physics itself does not register on an ammeter.

That is, to ask a physicist what the method of physics is and why use this method rather than some other is like asking a skilled driver how his car works, or a person who is very good at using WordStar how the program gets the words on the screen and formats paragraphs. *Using* a tool (and the method of science is a tool for the scientist) is one thing; *knowing how it works* is quite another.

Furthermore, different sciences use different variations on scientific method (though the traditional "five steps" of observation, hypothesis, experiment, theory, and verification, are pretty universal); but, of course, a physicist is an expert only at using the method of physics; and he is not skilled in biology or economics or psychology. Hence, his view of what science is "really doing" will be a view of what *physics* is doing, and may be quite different from what a psychologist would say science is "really about."

So the scientist is actually no better than anyone else in knowing how and why scientific method works, and what science is about—except for the fact that he works intimately with one particular science. But his special skills as a scientist do not adapt him to be able to investigate science itself scientifically.

And that is our purpose here.

• The object of this part of the book is to make a scientific investigation of science itself.

1.1.1. A logical difficulty

It might seem that we have got ourselves into a logical bind here, however. We would have to know what science is in order to do a scientific investigation of science—whose purpose is to find out what science is. That is, it would seem that we have to finish our investigation before we can begin it.

But this is more of a logical difficulty than a real one. We know that science observes its material carefully, that it forms hypotheses about it, and that when it is done with its theory, the theory accounts for the observed facts, or somehow makes sense out of them. I doubt if many scientists would have a problem with this description of what scientists are doing; the difficulty comes with what is meant by the terms.

1.2. The basic hypothesis about science

I am now going to state my basic hypothesis about what scientists are doing. The rest of this part of the book will be twofold: (1) developing the implications of the basic idea, and (2) going through what scientists seem actually to be doing (following the "five steps" of their method), and trying to show how this basic idea makes sense out of everything they do.

●HYPOTHESIS: Scientists are confronted with a set of facts that do not make sense (an effect); they are trying to find some fact that will make sense out of this effect (the cause).

That's it. Basically, it's that simple. Nor is there anything particularly new about it; the notion of "cause" as something that makes sense out of what doesn't otherwise make sense is as old as Aristotle, who defined "cause," basically, as the answer to the question "why?"; and as the Greek etymology of the term: *aitia* means literally, "what is asked for" or demanded; the "reason" for something.

The concept of "cause" has undergone all sorts of changes in the course of history, and to trace its evolution to its present-day meaning of "the act that precedes an event" or "the act that makes something happen" is, from a certain point of view, fascinating. Unfortunately, it is that present-day notion which has all sorts of difficulties connected with it, and has been legitimately rejected by philosophers of science.

So in a sense, what I am proposing here is that if you go back to the old Aristotelian notion of cause and effect, you will suddenly find that what modern scientists are doing—which seems on the face of it so mysterious—makes sense.

Why, for instance, do scientists make such detailed observations and measurements, and yet why is it a geologist wouldn't be interested if you gave him a list of every last stone in your back yard, with its location carefully marked, its weight carefully measured, its color and shape carefully noted?

Why do scientists contend that they deal with nothing but the observed facts, and then talk about electrons, genes, the unconscious mind, and so on, which cannot be observed?

Why is it that they accept some theories, like the theory that burning combines things with oxygen, and reject others that can't really be disproved, like the theory that burning gives off phlogiston, which has negative mass?

Why is it that they demand that theories predict things, and yet consider the "big bang" theory of the origin of the universe a good scientific theory, even if it can't predict anything (how could you "predict" how the universe got started)?

There are all kinds of problems connected with what scientists do, especially if you add what they are actually doing to what they say they are doing. And there are all kinds of theories which attempt to reconcile these apparently contradictory facts into a coherent view of what science is all about.

Taking the criteria scientists themselves use about theories, our theory will be a good one if it simply and logically accounts for all of the peculiar facts. That is, the simple assumption above (that scientists are trying to make sense out of what seems nonsense) should illuminate all these conundrums and show how they all make sense.

1.3. Scientific curiosity

As an illustration, before we get into a more detailed development of what we mean by "effect" and "cause," let us look at what starts the scientist going.

1.3. Scientific curiosity

Scientists contend that the first step in scientific method is careful observation. But I mentioned above that not every careful observation is a *scientific* observation, even if it uses measurement, and is very detailed and meticulous. The data to be observed *have to have scientific interest before* the scientist undertakes measuring them.

● **What initiates a scientific investigation is scientific curiosity.**

DEFINITION: *Scientific curiosity* is puzzlement when confronted with a set of facts that seem to contradict each other.

This is "why-type" curiosity, as opposed to "what-type" curiosity, when you simply don't know something. Even the taxonomist, who seems merely to be looking at plants or animals and examining their various points of similarity, is really not doing this in order to find out what things look like; he is doing it because he has noted in things that are apparently very different striking similarities "below the surface," as it were. How come the bones of vertebrates are so similar, so that you can call wings or fins "arms" and "hands"? How come the panda has a thumb? How come we have an appendix?

The reason the geologist isn't interested in the list of stones in your back yard is that he expects the stones there to be random sizes and shapes—and a superficial glance at your list shows that he was not mistaken. There is nothing there that he would **not** expect to find; and so he isn't interested in the fact that there were 53,476 stones, and the average weight was 1834 grams. He didn't know that fact; and once you tell him about it, he is going to make no effort at all to remember it.

So what starts scientists off is **not** what they **don't** know; they are ignorant of all sorts of things, from poetry to politics, and content to remain ignorant; and they are even ignorant of vast amounts of information in their own fields, and content to remain ignorant even of these facts.

No, what interests scientists is not the fact that they don't know things, but *something about what they do already know:* and what it is about what they already know is that what they know doesn't make sense.

For instance, if you took your list to the geologist and said, "It's funny. I was counting the stones in my back yard, and I found that on the left side of a line running right up the middle, they were mostly smooth; and on the right, they were rough and just any old shape." He might now perk up and ask if you were near a river—and if you said that there wasn't a river for miles, he might tell you that he'd like to look into this.

Why? Because stones aren't naturally smooth; they are smooth because they have been smoothed—usually by water. It doesn't make sense to have smooth stones in a place where there hasn't been any water, unless they have been dumped there. So the scientist's curiosity has been aroused.

1.3.1. The scientific assumption

Why does this apparently contradictory set of facts make the scientist curious—so curious that to satisfy it, he would be willing to spend years and even decades in a laboratory?

● **The scientist goes on the assumption that there is no such thing as a real contradiction.**

DEFINITION: A *contradiction* is something that is both true and false.

Put it another way: A contradiction is something that isn't what it is.

Well, of course it's nonsense to say that something isn't what it is; if it is what it is, then it isn't what it ain't.

Now it's possible for something to be one way at one time and another way at another time, or to be one way in one part of it and another way in another part—as, for instance, it was once true of you that you were a child, and now false that you are a child; or part of you is hard (your bones) and part of you is not hard (your skin). These are not contradictions.

It is only a contradiction when it is asserted that something *is now* the way it *now isn't*, when referring to the same aspect of the thing at the same time. Thus, it is a contradiction to say that there are words on this page and the page has no words on it.

This is not just a scientific assumption, of course.

● **No one can accept contradictions as really occurring.**

Why this is so belongs in the branch of philosophy called "epistemology." Basically, it is because if you say something isn't what it is, then you have no way of saying what it is in the first place—you have destroyed the possibility of knowing anything at all.

● **NOTE that the scientist does not necessarily think that things have to be "neat" or "orderly"; only that they can *not* be positively *contradictory.***

There is an important distinction here. Scientists would *like* the world to be "reasonable" in the sense of "the way reason would expect to see it"; but this is not a *demand* of reason, the way non-contradictoriness is.

For instance, the Periodic Table of the chemical elements lists elements by their basic chemical properties; and you find them falling into rows and columns, with chemicals of similar properties underneath each other, as with fluorine, chlorine, bromine, and iodine, for instance, all of which have a chemical valence of -1. But as you classify the elements, you then find that there are certain "boxes," which you would expect to contain just one element, that contain many different elements.

Of course, this peculiarity is something that makes the scientist curious; but it is not necessarily something that he says *can't* happen. The point here, however, is that the scientist can be content with a reality that doesn't fit a neatly preconceived pattern; but he absolutely cannot accept a universe in which there are contradictions, and what is is not what it is while it is what it is.

1.4. Effects and affected objects

Simply assuming that contradictions don't happen doesn't get you anywhere, of course, unless it seems to you that a contradiction did happen. Then there's something to be curious about.

DEFINITION: An *effect* is a set of facts which, taken by themselves, contradict each other.

That is, our definition of an "effect" describes the situation which makes the scientist curious. He seems to have *evidence* that a contradiction has really taken place; he knows some fact that indicates that X is so, and some other fact that indicates that X is not so.

Thus, our geologist friend knows that rocks are smoothed by water, thus indicating that the rocks in your back yard were either in a river or on an ocean beach. But he also knows that there is no river within miles and no ocean within thousands of miles.

Obviously, there are several possible explanations which make this set of facts not a real contradiction. They might have been hauled in from a beach; there might have once been a river bed where your back yard is; there might once have been an ocean shore where your yard now is. If any one of these is a fact, then there is no contradiction in the rocks in your yard being smooth.

Now the reason an effect is a set of facts which, *taken by themselves,* contradict each other is that the scientist *knows* by his assumption that he hasn't got the whole story. That is, if the rocks above were never near moving water—and if moving water is the only way they could turn out to be smooth—then they would not be smooth, when in fact they are. *That* would be a contradiction. But the geologist has no *direct* evidence that they ever were near moving water; hence, as far as the information he *now* has is concerned, he has a contradiction.

But the point is that he knows that the information he now has *is not all the information there is*, and that is why this situation is an effect and not simply a contradiction.

Now before we go any farther on this, let us make a distinction which will turn out to be important:

DEFINITION: The *effect* is *just the facts* that make up the contradiction (it contains nothing that is not part of the puzzle itself).

DEFINITION: The *affected object* is *the concrete thing* that contains the effect as *part* of itself. It may, in fact, be more than one thing; but the point is that it has characteristics that don't belong to the effect as such.

Let me illustrate. Let us say that you are Neil Armstrong on the moon, and you drop a feather and a hammer. They hit the moon at the same time. The effect, of course, here is that heavy things fall no faster than light things—though things fall because they have weight. So the hammer-*as-heavy-and-as-falling-at-a-certain-speed* and the feather-*as-lighter-but-as-falling-at-the-same-speed* are the characteristics of the feather and the hammer that belong to the effect.

The fact that one is a hammer and the other is a feather are part of the *affected object*, but *not* the effect, because they could be any two objects you want to name, as long as they are of different weights, and the *effect itself* would occur. The fact that the hammer is steel and the feather is organic, the fact that the hammer is silver and the feather while, etc., etc., are all irrelevant to the effect, and so are of no scientific interest.

In fact, these irrelevant aspects of the affected object tend to get in the scientist's way; because he sometimes (mistakenly) takes them as part of the effect. We will see this later.

So the effect is just those aspects of the affected object which do not make sense by themselves.

● **NOTE that very often one side of the contradiction that makes up the effect is some well-established *scientific theory* that the scientist takes as a fact.**

This is why some philosophers of science have noted that scientific observation is often "theory laden." For instance, the apparent contradiction in having heavy and light things fall (in airless places) is partly due to the fact that we see them fall, generally, when air resistance makes the light one fall slower; but it was also due to Aristotle's (apparently well-established) *theory* that falling bodies "seek" their "natural place" more or less forcefully depending on the "mixture of their elements of earth, air, fire, and water."

The point here is not that theories determine what observations the scientist is making, but that well-established theories lead you to **expect** certain things as facts; and when you observe something that contradicts these expectations, you have an effect.

Already, then, our hypothesis explains something philosophers of science have found puzzling: why scientists don't just begin observing; and why, though they seem to be studying *facts*, their observations usually begin from a background of some *previous theory.*

1.4.1. Other attitudes toward effects Seeing an apparently contradictory situation makes the scientist curious. It obviously doesn't have that effect on everyone. It might be useful to distinguish the various ways we react on being confronted with something that seems to be a contradiction.

DEFINITION: A situation is called *funny* when the facts contradict the way we expect them to be, and we *simply tecognize the situation.*

Here is the difference between "funny-ha-ha" and "funny-peculiar." They are both the same thing; the actual facts aren't what we expect them to be. If we simply accept this, then we laugh; if we say, "Now wait a minute, how can that happen?" we have noticed an effect (and we are about to start looking for a cause).

Noticing an effect involves a *dissatisfaction,* then, with what is observed; laughing at it does not; it simply accepts it.

DEFINITION A situation is called *bad* when the facts contradict the way we expect them to be, and *we refuse to accept them.* The psychological experience here is neither curiosity nor humor, but *suffering.*

That is, the scientist is *curious* when he confronts something that his reason tells him "ought not to be happening." And he then looks for a cause which will *explain how* the situation really isn't a contradiction. So, for instance, a scientist investigating a person who has suddenly gone blind will wonder how it is that he could see yesterday, and now all of a sudden he can't. And as a scientist, he will look to find out what explains the sudden lack of sight.

The blind person himself, however, is not really interested in the cause of his blindness—except insofar as knowing it might lead to a cure. If he can be cured without ever finding the cause, he doesn't care *why* he got blind. He regards *being blind* as *bad;* and what he wants is to *change the facts* until they agree with his idea of the way the facts "ought" to be.

The point of all of this, of course, is that not everyone confronted with an effect is motivated to start a scientific investigation; he might suffer it, or laugh it off. It is only the scientist who can't rest until he finds what fact makes sense out of the effect.

1.5. First step: observation

Now then, what does the scientist do when he notices an effect? He doesn't immediately leap to a conclusion. That's what most of us do, and we come out with some pretty strange theories, which, if we had been more careful, we would have seen couldn't be the real explanation for our effect.

And the very first thing we should have done that the scientist is careful to do is make a careful observation of all the aspects of the effect as such.

● **The first step in scientific method is *observe carefully the effect.***

● **One of the most difficult parts of scientific observation is separating out the effect from the affected object.**

1.5. First step: observation

Of course, what you observe is a concrete situation (an affected object) with all sorts of details, any one of which may be part of the effect, and then again may not.

For instance, to take falling bodies as the effect, we usually see them fall in air. It seems clear that things fall because they are heavy; and this might lead us to ignore the air resistance as irrelevant and part of the affected object. It turns out, however, that air resistance messes up how fast a body will fall; and unless you check to see whether it's relevant or not to the speed of fall, then you'll miss the most peculiar part of the effect.

Or again, people laughed at Gregor Mendel when he was observing how pea plants had characteristics that were transmitted from parent to offspring in definite ratios. The plants were either tall or short (to take just one characteristic), and depending on the parentage, you could predict either tall or short plants (and in a definite ratio), but none in between. This, of course, flies in the face of the fact that a black person marrying a white one will not have a certain number of children black and another number white; there are all the intermediate colors.

We know now that this is because there are many genes determining things like skin color; but Mendel's observations got at the effect itself, and observations of things like skin color involve part of the affected object.

But how do you separate out the effect from the irrelevant aspects of the affected object?

—Ah, that is the difficulty. There are no real rules for this; it is the genius that sees things in a certain peculiar light who seems to be able to do it. But even he only knows he has done it when he gets through the whole process and finds that his insight into just what the "problem" to be solved (the effect) is was correct.

So for those of you who want science to be a mechanical process where you can make great discoveries by just following rules, I am sorry to disappoint you. Right here at the beginning, seeing what the effect is, is what separates the great scientific geniuses from the rule-followers; and, as history has so abundantly verified, there are no rules for seeing what the problem is.

But by the same token, this is what makes science exciting; it isn't by plodding along in a mechanical way, following rules, that great breakthroughs occur; it's by seeing things in a new light—and this can happen even with novices in science. In fact, it's the young people who tend to make the great breakthroughs, because they haven't got the traditional thought-patterns established yet. They look at things in a way that the traditional scientist thinks of as stupid, naive, or weird; and he says, "Why do it that way?" and they answer, "Well, why not?" And sometimes—unfortunately, only sometimes—this weird point of view is the lens that focuses on the real problem and not side issues.

• **The point to note here, however, is that what the scientist is observing is not just a fact or set of facts, but an *effect*.** He wants first of all to discover *in just what way* things don't make sense—before he attempts to find out what makes sense out of them.

1.6. Explanations If there aren't any real contradictions and things don't make sense by themselves, then obviously they aren't really "by themselves." There has to be some *fact* that the scientist hasn't yet observed which will make sense out of the effect.

First note that the fact that makes sense out of the effect has to be *missing* from the observation, or no effect would have been observed. For instance, you wouldn't have been curious about the smooth stones in your back yard if you had seen a truck drive up and dump them. (You might, of course, be curious as to why the trucker did this, if, say, you hadn't ordered them dumped; but you wouldn't be curious about how smooth stones got there).

Secondly, note that this missing information that creates an effect *has to be a fact* and isn't something just "made up" by the scientist to satisfy his mind; because if the whatever-it-is that "makes sense out of" the effect is *just* in the scientist's mind, then there really *is* a contradiction—which means that there really is something that really isn't what it really is.

So this is no game the scientist is playing. He *knows* that there's a fact missing from what he has observed; and since that fact *really exists,* then it's at least in principle possible to find it.

And this is what drives scientists onward: the knowledge that the goal (the explanation) is not just a dream, or something like the Holy Grail, where the "quest for the ideal" is supposed to be what's important, even if the goal doesn't exist; this goal is really there. All that's needed is the ingenuity to find it.

DEFINITION: A *theoretical problem* is the same as an *effect.*

DEFINITION: A *practical problem* can be stated as the following type of contradiction: "I intend to do X; the facts I know indicate that it is not possible for me to do X."

• The difference between theoretical and practical problems is that theoretical problems *always* have solutions, but practical problems do not always have them.

That is, it might really not be possible for you to do X, however much you might want to do it, because things are really limited, and you might be going beyond the limits of what you're dealing with. Of course, you might simply *think* you know what the limits are, and your practical problem might actually be solvable. It's a problem because it *seems* you can't do what you want to do; but the seeming may or may not be accurate.

On the other hand, as I said above, theoretical problems are guaranteed to have solutions; and if you don't find one, it isn't because there isn't one. There are no real contradictions.

DEFINITION: An *explanation* is a *possible situation* which, if it were a fact, would make the effect make sense.

That is, an explanation may or may not be a fact, but if it is a fact, then this fact would make sense out of the effect in question.

For instance, one explanation of the smooth stones in your back yard is that they were dumped there by someone. Now you don't know, just from your observation (supposing that you didn't see it happen) that they were dumped there; but if they were, then it makes sense for them to be there.

Another explanation is that this land was once a riverbed. Again, you don't know from observation that it was; but if it was, then your problem is solved.

● **NOTE that there are *an infinity of explanations* for any given effect**.

Some of these explanations might be more far-fetched than others. For instance, that there were little gnomes who lived beneath the ground in your yard and came out at night and filed the stones smooth. That's an explanation; if there were such things and they did this, then the stones would be smooth.

So all an explanation has to be is not itself contradictory; it doesn't have to be a fact to be an explanation. Obviously, if it contradicts itself, then it doesn't make sense itself—and so it can't make sense out of anything else. The gnomes above don't involve a contradiction; there just aren't (so far as we know) such things; but they could exist, in the sense that there's nothing about them that contradicts anything else about them. Explanations have to be *possible* (not self-contradictory) to be explanations; but they don't have to be *factual*.

Obviously, scientists aren't really interested in the explanations that aren't facts; they want to know what really does make the effect not really a contradiction.

That is, once the scientist finds out that someone dumped the stones in your yard, he's satisfied; and if you pester him with, "Well, but they could have been on a riverbed there anyway," he won't listen to you—unless you can show him that not all the stones can be explained by the dump truck.

1.6.1. The logic of explanation Modern philosophers of science have noticed that scientific theories are of the form "if (theory), then (data)." Our theory of science interprets this as "if (explanation), then (effect)." That is, the effect forms the "then" clause of an "if-then" type of sentence.

Now the logic of "if-then" is such that, supposing the connection between the if-part and the then-part to be true (i.e., supposing that the whole statement describes a state of affairs such that the "then"-part is connected somehow with the "if"-part, so that whenever the "if" occurs, the "then" also will happen), then (a) knowing (by observation) that the "if" has happened, it *must* be the case that the "then" also occurs.; or (b) knowing that the "then" has not occurred it *must* be the case that the "if" *has not occurred either*.

This sounds confusing, so let me give an example.

The statement, "If it is raining out, then the cat is inside" asserts a connection between the weather and the cat (i.e. that the cat hates the rain enough so that *whenever* it's raining, the cat will go in). For purposes of this example, we have to take the statement as universally true, so that there never are instances when the cat is caught outside in the rain.

Now then, if you see that it's raining out, you don't have to waste your time looking outside for the cat; because **if** it's raining out, the cat is inside.

On the other hand, if you look out your window on a cloudy day and see the cat outside, then you know it hasn't started to rain yet; because if it's raining, then the cat is *in*side.

- **NOTE, however,** that the if-then statement is *not* an if-and-only-if-then statement. It only asserts that whenever the "if" is true, the "then" is also true, but **not** that when the "if" is *false*, the then is also false.

That is, you know that if it's raining out, the cat is inside; but the cat is sometimes inside *also* when it's sunny. The cat is *always* inside when it rains; but sometimes inside when it isn't raining (e.g. it may also be the case that the cat is inside when there's a dog in the neighborhood—whether it's raining out or not).

Hence, from the if-then statement you can conclude nothing *from* either (a) the *falseness* of the "if" or (b) the *truth* of the "then."

That is, if you see that the sun is shining, you can't tell from that whether the cat is inside or not; or if you see the cat inside, you can't tell that it's raining out.

Now why is this important for scientific investigations?

Because, as I said, the logic of the scientific explanation is "if (explanation), then (observed effect)." And that means that if you happen to know that the explanation is a fact, it follows that the effect will occur; or if you happen to know that the effect *doesn't* happen, then you know that the explanation can't be a fact.

But the difficulty is that what you know from direct observation is the *truth* (the factuality) of the *effect*, which is the then-part of the statement. But from the truth of the "then," you can reach no conclusion as to the truth or falseness of the "if" (the explanation). That is, you have looked and seen the cat inside, so to speak; but you can't conclude that it's actually raining out.

● It is *not* possible to *prove logically* that a particular scientific explanation is *the true one.*

There are, as I said, an infinity of explanations for any given effect; and any one of them fits the "if-then" logic; so that, if it is a fact, then the effect makes sense. Hence, the actual observed occurrence of the effect does not pick out any one of the explanations as the true one. The fact that the cat is inside doesn't mean you can say that it's raining out; because it might be sunny and there's dog in the neighborhood.

That's maddening, isn't it?

However, there is one thing you can do, logically. If the then-part is *false,* then either the if-part is false or (and this is the possibility we ignored earlier), the *connection itself is false.*

Thus, if you see the cat outside, then it must either be that it's not raining or that you misunderstood the connection between the cat and the rain (i.e. it's not true that whenever it's raining, then the cat is inside).

How does this apply to science?

If you find out some aspect of the effect that the explanation says *has* to occur, and you observe that it doesn't occur, *then you know that this is* ***not*** *the true explanation of the effect.*

● Scientific explanations can be *falsified* by showing that they "explain" something that does not actually happen.

We will see how this works later; but for now, just let this example suffice: You explain the line of smooth stones in your back yard by supposing that they were in a riverbed. You then look at the yards adjoining yours on both sides, and you find no smooth stones that would continue the line.

But if there was a river, then it would have had to have risen in a spring from your property line, and sunk into the earth at your other property line. Absurd. That is, the explanation that the stones were there because of a river that ran through your property would *also* demand that it be a fact that (because the river would not just be on your property) there be stones along the line on the other properties. But there aren't. Hence, this explanation of the stones is false.

1.6.2. A modern complication

The philosophy of science of a few years ago has added a complication to this treatment of the logic of scientific explanation, and a word about it is due here. Scientists like to do mathematics (for reasons we'll discuss later); and philosophers of science are either scientists or are interested in science; and so they like mathematics also.

There was, then, an attempt to "mathematize" logic, which is still regarded as valid. But a difficulty comes in precisely this "if-then" statement, because traditionally—as I mentioned above—no conclusion can be drawn from the falseness of the "if" or the truth of the "then."

But this messes up the mathematical "truth-tables," because you have to put question marks in some of the boxes, instead of being able to fill all possibilities with T's or F's. [If this doesn't make a great deal of sense to you, don't worry about it.] Mathematics likes closed systems, where everything is defined, and there aren't any "maybe's"; and so the inventors of symbolic (mathematical) logic decided to create a convention.

Based on statements like, "If you win this race, I'll eat my hat," where what the person means is "No way I'll eat my hat; you're not going to win this race."—or the person is emphasizing the *falseness* of the "if" by connecting it with something impossible—based, as I say, on such statements, the mathematical logicians said, "Let's say that anything follows from a false statement." Hence, the "new-logic" of what they call "material implication" is that if you know that the "if" is *false*, you can conclude that the *then is true*. Instead of not concluding anything. [Of course, you can also conclude to a false statement. That is, the *connection* is valid when the "if" is false, whether the "then" is true or false; so a conclusion can be drawn; but *any* conclusion can be drawn. If this sounds silly to you, you're not a mathematician.]

But when you apply this to science, then this means that *when the explanation is false, the scientific theory (the connection) is a good theory!*

That is, by "material implication" and symbolic logic, the statement, "If phlogiston is given off in burning, then the products of combustion weigh more afterwards than they did before" is a **true** statement **because** phlogiston is **not** given off in burning.

You might say, "Well yes, but **if** it were, then this would explain why the products weigh more." True; but the following statement would also make a good theory: "If Los Angeles is a suburb of Tokyo, then the products of combustion weigh more afterwards than before burning." Because it's false that Los Angeles is a suburb of Tokyo, then it *"follows logically"* that the products of combustion weigh more—because "anything follows from a false statement."

This is logic?

Philosophers of science have tied themselves into knots trying to make this sort of thing not totally ridiculous; but they haven't really succeeded. And it isn't surprising, because this convention to make logic fit into a mathematical scheme contradicts the way we use words. (See *Modes of the Finite*, Volume 4 for greater detail, if you're interested.)

1.7. Evidence So let us leave contemporary logicians to polish the ivory in their towers and get back to one more thing before we try to follow the scientist in his search for the true explanation of the effect he has observed.

Scientists are very fond of saying that they are looking for evidence; and when you make a statement of any sort, they want you to give the evidence for it. What are they talking about?

DEFINITION: The *evidence* for the truth of a statement is some admitted fact which *could not be a fact* if the statement in question were *false*.

That is, a statement is evidence for another if it fits into the following scheme "If (evidence), then (fact in question); and (evidence is true)." We saw by the logic of "if-then" that if the connection is true and the "if" is true, the "then" *must* be true. Hence, the truth of the "if" *proves* the truth of the "then"—and that is what we mean by "is evidence for."

So two things are needed for evidence: (a) to show that the statement in question logically follows from the alleged evidence (i.e. that the connection is valid); and (b) that the alleged evidence is a fact.

● **What this all amounts to is that the fact in question is an *effect* of the evidence which is its *true explanation*.**

You have to be able to show, however, that the evidence is not just *an* explanation of the fact in question, but the *true* one.

Let me give an example. In a law case, the witness testifies that he saw the defendant shoot the victim. He is then cross-examined by the defense attorney, and in the course of the examination, it becomes clear that (a) the witness is not lying, because he is suffering because of his testimony, and people don't lie when it's to their disadvantage to do so; and (b) he couldn't have been mistaken about what he saw, because he was too close to the scene to have been fooled. So he must have seen the shooting.

But it is impossible for him to have seen the shooting and the shooting not to have occurred. Hence, his testimony, having been established as a fact, is evidence for the prosecution.

To take another example, evidence that the stones in your back yard were not due to a river is the observed fact that there aren't smooth stones where the river would have to have been. This lack of smooth stones would make it impossible for the river to have been there.

● **Some things are *self-evident.***

Generally speaking, directly observed facts are self-evident. If you "see it with your own eyes," you need no evidence except the observation itself to prove what it was you saw.

There is, of course, the possibility that you could have been mistaken, especially under extreme conditions. For instance, if you see something in dim light, then you might have reason for not trusting your eyes, and you might need evidence that what you thought you saw was what you actually saw—evidence you might get by asking someone else, for instance.

● **Your own experience that you are having a certain experience is *immediately evident.***

"Immediately" here means "without any medium or anything 'between.'" That is, if you think you see a red apple in front of you, you might conceivably be mistaken and there isn't actually an apple there; but you can't be mistaken *that you're having the experience of seeing-an-apple-in-front-of-you;* the experience is always *also* the experience-of-the-experience; they are one and the same thing; and so, this kind of thing is not only self-evident, it's immediately evident. There is no possibility that you could be mistaken here.

Generally speaking, however, if we are careful (and scientists are), we don't have to go all the way back to what is immediately evident; we can take the direct evidence of observation as self-evident (and not needing proof), and use this as our evidence for things that we can't directly observe.

And this is why science relies on direct observation. Science is looking for explanations; but the explanations are not themselves observed (and, as we will see, sometimes can't be); and so must somehow be proved to be the true ones. But the evidence for them must then be something that **is** directly observed.

So our theory of science explains why scientists rely so heavily on direct observation. But let us now see how scientists take explanations and try to weed out the true one from all the ones that could be true but aren't.

CHAPTER 2

THE CAUSE AND ITS PROPERTIES

2.1. Second step: hypothesis

The scientist, then, is not justlooking for an explanation of the effect; he is looking for the true one: the one that actually exists and actually does make the effect not a contradiction.

But of course in order to do this, he has to think up an explanation, and probably a lot of them, so that he can pick out the one which is most likely to be the right one.

Again we're in a place that has few rules, really. It takes ingenuity to be able to dream up explanations for a given effect, and common sense to be able to reject the explanations that are not worth pursuing. Nobody would have any trouble rejecting the explanation that gnomes filed down the stones in your back yard, but it might not be so easy to eliminate others without further investigation.

In any case, what the scientist does is pick out one of the explanations he has come up with and use that as his *working hypothesis*. He is now going to test it to see if it is the true one.

DEFINITION: A *hypothesis* is an explanation of the effect in question, which will be tested to see if it is the one which is actually the fact which makes sense out of the effect.

It is called a "hypothesis" because a hypothesis is the "if" clause of an "if-then" statement. Hence, the hypothesis is put into the explanatory statement: "If the stones were dumped in your back yard, then the fact that they are smooth makes sense." You will recall that our hypothesis about science is "If science is looking for the true explanation of effects, then the peculiarities about scientific method make sense."

2.1.1. Occam's razor: simplicity

We are not totally without rules, however, even at this stage of the enterprise. We can rely on what is called "Occam's Razor," after William of Occam, who told us we should "cut away" from our consideration any explanation that involved us in assuming the existence of a lot of unobservable things (like the gnomes).

● **Of all the explanations, the simplest is most likely to be the true one.**

DEFINITION: An explanation is *simple* if it assumes *the fewest possible* facts that are not directly in evidence.

We will return to simplicity later, when we discuss the criteria of a good scientific theory; and we will then see **why,** on our theory, a scientific theory is a good one if it is simple. At this point, it just sort of "stands to reason" that if you can explain something by assuming only one fact you can't directly observe (remember, the effect wouldn't be an effect if you observed what made sense out of it), then this is a better explanation than one that means you have to accept as true a dozen facts you have no direct knowledge of.

(Note that the problem is that the simple explanation may be better, but does that make it *truer*?—and after all, the scientist is interested in the one that's actually the case, not in what is "neat." We'll see this later.)

Our own explanation of science is a simple one: all we assume is that scientists, confronted with facts that don't make sense, are trying to find the fact that makes sense out of this effect.

● NOTE that simplicity does not mean that the explanation is easy to understand or that the logic by which it explains the effect is easy to follow; it only means that you don't make up a lot of unobserved "facts"

The reason I say this will become evident in the next few pages. We are now going to have to take a look at this "true explanation" that the scientist is trying to discover. And it will turn out that there are quite a few ramifications to it.

2.2. Cause and causer

If you refer back to section 1.2. on page 9, where I stated the basic hypothesis about science originally, I called the fact that made sense out of the effect the "cause." It is now time to make a technical definition of this.

DEFINITION: The *cause* is the *true explanation:* it is the *fact* which in fact makes sense out of the effect. The *cause* contains *only what is necessary* to make the effect not a real contradiction.

DEFINITION: The *causer* of a given effect is *the concrete object* or set of objects which are doing the causing: that is, which

contain the cause as part of themselves.

The distinction between cause and causer parallels the distinction between "effect" and "affected object" which we made earlier (on page 15).

In the example we gave there, with Neil Armstrong dropping the hammer and the feather in the airless space of the moon, where they hit the moon at the same time, we noted that the shape, color, size, and so on of the two objects were irrelevant to the *effect itself* and were part of the "affected object," because any two objects of different weight would do as illustrating the problem.

Of course, it was the *moon* that attracted these two objects to it; and if they had been dropped in a vacuum chamber on earth it would have been the earth that attracted them. But you can see that it's irrelevant *what the nature of the moon as opposed to the earth* is, since in both cases, the objects will fall at the same speed. The only thing that is needed is that *what makes the objects fall is extremely massive in comparison with the objects themselves.*

Hence, bodies of unequal weights will fall with no detectable difference in acceleration (to be technical about it) if the body they are falling toward is many many times as massive as they are. If it isn't, then complications (which we need not go into) arise. The point here is that anything else about the attracting body is irrelevant to it as explaining the accelerations of the falling bodies.

Hence, the *massiveness* of the moon or the earth is part of the **cause**; the chemical constitution of the earth and the moon, the relative sizes of the two bodies, the place in the solar system, the color, and all the other qualities that belong to the objects as they concretely exist are part of the *causer but NOT of the cause.*

This distinction between cause and causer is very important, because including parts of the causer into the cause is going to give you an explanation that is apt to be false. In fact, one of the biggest mistakes in modern philosophy involved precisely a failure to make this distinction.

René Descartes noticed that if he were thinking at all, he could not doubt his existence; and so he made the famous statement, "I think, therefore I am." From this, however, he concluded that the "I" was *only* a thinker (a mind), and that I *have* a body, which is a different thing from myself. The "I" **as** a mind is the *cause* of thinking; but the "I" as *causer* is actually a body which has a mind as one of its faculties or "powers." Descartes failure to make this distinction split the human being in two, and philosophers since then have been trying to put "them" together again.

2.2.1. Effect and cause as abstract

One of the first things to note, then, about the effect and the cause as we have defined them is that they are abstract aspects of a concrete situation. They are *not* concrete things themselves; the effect will always be only *part* of the whole situation which is observed, and there will always be properties of the observed affected object which have nothing to do with it as effect. Similarly, the cause will always be part of a larger situation which contains properties which have nothing to do with it as explaining the effect in question.

This does not mean that the effect and the cause are not *real*. They are *real aspects* of a concrete situation, but only aspects of it. Just as the color of a red ball is red, and the color is real, even though it is not a "thing" itself (it is a way the ball exists), similarly, the fact that the effect is an aspect of an affected object doesn't mean it isn't a real aspect of it; and the same goes for the cause. The cause **has** to be real, or the effect would be a real contradiction, and that is impossible. But the cause **isn't** a thing; it's an aspect of something.

● **NOTE that aspects of the causer that are not part of the cause**

cannot be known by arguing from the effect.

Why is this? Because these aspects of the causer could be anything at all, and the effect would still be explained by the causer (because all that is needed to explain it is the cause—and by the supposition, the irrelevant aspects have nothing to do with it, and so can vary without affecting it). Thus, we could go to Jupiter and perform the experiment with the feather and the hammer (if we could find a vacuum there), or Mercury, or the Sun, or any very massive body—and the effect would be always that, dropped from the same height, they'd reach the surface at the same time.

Hence *from this effect as defined* you cannot tell *anything* about what planet you're on except that it's very massive with respect to what you're dropping.

● It follows from this that science will never tell us all about reality.

Science, looking for **causes,** will only tell us *aspects* of the real concrete reality. They will be aspects that will have to be real ones; but they will always leave out some of the real aspects of the situation—the aspects that belong to the causer and not the cause.

To put this another way:

● What is necessary does not exhaust what is real.

Why is that? Because of the following:

● A *fact* is not of itself an *effect.*

That is, in order for a fact to need explaining, it has to be a contradiction taken by itself; but not every fact is a contradiction when taken by itself; in itself, it's just a fact. You have to have **two** facts that "fight" in order to have an effect.

So there may very well be all kinds of facts that don't need explaining as such; and there has to be at least one. If **every** fact needed an explanation, then no explanation would be possible; the whole set of all effects with their causes would itself be an effect—for which there could not be a cause, because it by definition would have to be outside the set, which would put it inside the set.

And so there are some facts that are just facts and don't need causes; and there are aspects of the causers that are just facts and have nothing to do with what is necessary to explain what effects there are.

"There is more in heaven and earth, Horatio, than is dreamed of in your philosophy." It is the *rationalist fallacy* to assume that because something **is** a certain way, it *has to be* that way. This might be so; but there is no reason why it *has* to be so; and, using Occam's razor, if there is no reason for assuming it to be so, we shouldn't do so—because we certainly don't observe that things always have to be the way they are.

Now then, with that out of the way, we can note that

● Since effect and cause are abstract, exactly what the effect is depends on which facts you notice; and the cause will differ depending on what you see as the effect.

This sounds as if the whole thing is subjective; but I can illustrate what I am saying by taking the hammer and the feather on the moon and the earth. If the effect you are interested in is the fact that a heavy and a light object fall at no detectable difference in acceleration, then the effect of the hammer and the feather as falling on the earth and the moon is identical in both cases; and the fact that the earth is more massive than the moon makes no difference.

If, however, you measure *how fast* the hammer and the feather fall to the moon, and how fast they fall to the earth in a vacuum, you will note that both the hammer and the feather fall toward the moon at the same speed *as each other*, but this speed is *different* from the speed at which they both fall to the earth.

Your effect now has become more complicated. You are now asking "Why is it that heavy and light objects fall at the same rate of acceleration as each other; but that this rate of acceleration is different depending on the body they are falling toward?"

The degree of massiveness of the earth and the moon are now part of the effect; and so the cause has to explain this added complication. And the cause will be *the fact that differences in massiveness of the attracting body will produce different speeds of attraction*. That is, the cause now takes into account the fact that (a) massiveness explains falling, and (b) differences in massiveness explain differences in speeds of falling.

This doesn't make your first effect-cause linkup **false**; it is still true that the massiveness of the attracting body, if it is very great, will make bodies of different (small) masses fall at (for practical purposes) the same acceleration. The added factor is part of the *causer* of the effect stated in this simpler way; when you add the difference in the actual rates of acceleration as part of the effect, then this part of the causer slips into being part of the cause of this *new* effect.

That is, the two effects (bodies of different weights hit the surface at the same time; bodies of different weights fall at one rate of acceleration on earth but a different rate of acceleration on the moon, etc.) are *two different* effects—slightly different, but different. Hence, the causes (as opposed to the causers) will be different.

2.2.1. Effect and cause as abstract

2.3. Theorems about cause

This is an interesting development; let us look at it more closely. It turns out that we can, from our definitions of effect and cause, derive some **theorems** about effects and causes.

DEFINITION: A *theorem* is a statement that is necessarily true just because of the way the terms involved in it are defined.

● **THEOREM 1: Identical effects have identical causes.**

The way this theorem can be proved is the following. Assume that you have two effects that are identical (whether the affected objects are identical or not). Now the cause of Effect 1 has *all* the properties *necessary* to make sense out of effect one, and *only* the properties which are *necessary*. All other properties belong to the *causer* of effect 1. The same is true of the cause of Effect 2.

Call the cause of Effect 1 Cause 1, and the cause of Effect 2, Cause 2. What is to be proved is that Cause 1 must have exactly the same properties as Cause 2.

Suppose Cause 1 has a property that Cause 2 lacks. Then this property will be *necessary* to explain Effect 1, but not necessary to explain Effect 2. But Effect 2 is identical with Effect 1; and since the effects are *abstract properties* of the affected object, then if they are identical, you can substitute one for the other without changing anything. Then substitute Effect 2 for Effect 1. But now Cause 1 has a property which is *not necessary* to explain the "new" Effect 1, which is identical with the "old" one. But that means that it was not necessary to explain the old one either. Hence, Cause 1 cannot have a property that Cause 2 lacks.

If Cause 1 lacks a property that Cause 2 has, then when we substitute Effect 2 for Effect 1, Cause 1 will now *not be able* to explain the "new" Effect 1, because it lacks what is *necessary* to explain Effect 2, which is the "new" Effect 1. But since the "new" Effect 1 is identical with the "old" one, Cause 1 was not able to explain the old Effect 1 either.

Hence, Cause 1 can neither contain nor lack any property that is in Cause 2. They must have the same properties. Q. E. D.[1]

If we use as our example the hammer and the feather falling on the earth and the moon and note as our effect **only** the fact that both bodies hit the surface together if dropped from the same height, then the difference in massiveness of the earth and the moon are irrelevant to the explanation of *this* effect. Both the earth and the moon are very massive with respect to the attracted objects, and this is all that is necessary to explain the effect. Hence, *as causes* they are identical.

● THEOREM 2: Different effects have different causes.

To prove this theorem, we note that an effect is defined as such by the fact that there is a *fact missing from its intelligibility.* It appears as a contradiction only because the fact which explains it was not observed; hence the fact that this fact (the cause) is *missing* is what makes the effect an effect.

It follows from this that what makes one effect different from another *as* an effect is *specifically which fact is missing from its intelligibility.* That is, if **a** fact of some sort is missing, you have an effect in general; if *this particular fact* is missing, you have this particular effect.

But the missing fact is precisely the cause; and therefore, one effect is different from another *if and only if its cause is different from*

[1]"Quod erat demonstrandum" (What was to be demonstrated) The classic conclusion of a theorem in geometry.

the other. Q. E. D.

Again, if you take as the effect in question the fact that the rate of acceleration of falling bodies on earth is 32 ft/sec^2, and on the moon it is different, then whatever it is that is attractive about the earth *cannot* be the same as that on the moon, or they would make the bodies fall at the same rate.

Once having proved both of these theorems, there are two *corollaries* which follow:

COROLLARY 1: Identical causes have identical effects

Suppose Cause 1 is identical with Cause 2, but their effects are different. Then you have a case of different effects with identical causes, which is disproved by Theorem 2.

COROLLARY 2: Different causes have different effects.

Suppose Cause 1 is different from Cause 2, but their effects are identical. Then you have a case of identical effects with different causes, which is disproved by Theorem 1.

2.3.1. Analogy There is one more thing we can do with effects and causes, which will give us something useful.

COROLLARY 3: Similar effects have analogous causes.

DEFINITION: Objects are *similar* if they are partly identical and partly different—and it can be *observed* in what respects they are identical and different.

DEFINITION: Objects are analogous if they are partly identical

and partly different, but the *respects* in which they are identical and different *are not known from observation.*

That is, when you say two things are similar, you can point to what they have in common, and what makes them different. If you say they are *analogous*, you know (for some reason) *that* they are (somehow) similar, but you don't know *in what respect* they are identical or in exactly what way they differ.

So similarity is called "analogy" when *only the fact of being similar* is known—not the precise way in which the things are similar.

Now then, to prove the theorem, if two effects are similar, then as effects they are partly identical and partly different. By Theorem 1, the respects in which the two are identical demands that the causes be identical; and by Theorem 2, the respects in which the two are different demands that the causes be different. Hence, the causes of similar effects will themselves be partly identical and partly different.

But since the causes are not observed merely by arguing to them from the effects, all you know from this reasoning is *that* they are somehow identical and somehow different from each other; but you do not in general know in what respects this is so. But this means that the causes will be analogous. Q. E. D.

COROLLARY 4: Similar causes have analogous effects.

The reasoning is the same. As identical, the causes will have identical effects, and as different they will have different ones; hence the effects will be partly identical and partly different; but again the precise respects in which this is true cannot be known just from knowing the causes. But this means the effects must be called analogous. Q. E. D.

2.3.1. Analogy

Let me illustrate before I make an important point suggested by this.

If we combine the two effects about bodies falling on the earth and the moon into the similar effects that both the heavy and the light body hit the surface together, but the rate of fall on the earth is different from that of the moon, we can conclude that *whatever it is that causes the fall on the moon is partly identical to what causes the fall on the earth* (because in each case, light and heavy bodies are treated equally), *but there must be some difference in the cause as it exists on the moon and the earth, or the rates of fall would be the same also.*

But what **is** it about the earth and the moon that makes bodies fall towards it? Ah, there is the difficulty. We know that it's connected with the massiveness of the earth, the moon, the hammer, and the feather. But what is it exactly? Newton thought it was a *force* attached to the mass of an object, which varied directly as the product of the two masses involved, and inversely as the distance between their centers. (I.e. $F = K$(some constant)Mm/r^2).

By this theory, if M (the earth's mass, say) is very large with respect to m (that of the hammer), then m adds nothing to it, for practical purposes (i.e. 1,000,000 x.0002 is just about the same as 1,000,000 x .0004); and so all bodies we can lift will add nothing significant to the product Mm. And if r is the distance from the falling body's center to the center of the earth, then lifting the body up another couple of feet is not going to make this number measurably different. So under these conditions, the whole fraction turns out to be the same all the time—and so four-pound objects fall just as fast as four-ounce objects. (Actually, as you can see, they don't; but the difference is so small as not to be measurable.)

But, by this theory, if M on earth is different from M on the moon by any large amount (and it is), then the reasoning above will apply to the moon as well as the earth, but the actual number the fraction comes out to will be different.

Einstein, however, showed (for reasons we don't have to go into here), that there could not be such a force; and he explained falling bodies by a warping of the geometry of space (actually space-time)—and the geometry of space was the path that a falling body had to fall along. Since greater mass warped space more, then the fall would be different—and would come out to the observed rates of fall.

If you're lost here, the point is that *we don't really know what it is that explains why bodies fall,* because we can't observe it. But we do know this: whatever it is, it is connected with whatever is responsible for the weight and resistance to acceleration of a body (its "mass"); and all bodies have this tendency to be attracted, but the tendency varies depending on the variation of this "mass," whatever it is.

In other words, because the effects are similar, whatever is responsible for the effects is *somehow* similar; but we don't know in just what way. One theory is that it is a greater or lesser force of the same type; the other says that the identity is in a warping of space-time, and the difference is in degree of warp.

So the causes of falling bodies are analogous with each other.

It turns out that many concepts in science are analogous. Energy, for instance is an analogous concept. We know that electricity and heat are somehow the same, because both can move things; but they aren't identical because things are moved in different ways under the influence of heat and electricity. So we give the analogous name "energy" to whatever can account for such similar effects.

We will see later how the concept of analogy helps in explaining the use of *model*s in scientific theories; but let me give a brief account of why I use this term here.

Historically, "analogy" was defined more or less as I defined "similarity"; but the real problem of analogy arose in philosophy in reference to terms used to apply both to finite things and the Supreme Being. For instance, we are good and intelligent, and the Supreme Being is known to be good and intelligent.

But since the Supreme Being is infinite and has no unified "set" of "properties," but is one simple Act, then goodness, intelligence, mercy, justice, etc., in Him are all different names for the same thing, while in us they are different aspects of ourselves. For instance, we can be just without being intelligent; but the Supreme Being can't be, because these are just different ways of naming His Act.

Yet it was also known that it would be false to say that the Supreme being is *not* good or *not* intelligent, and so on; and so the dilemma arose of how you could know these terms applied to the Supreme Being when you couldn't see Him and they obviously meant something different when applied to Him than when applied to us.

Various attempts were made to solve the puzzle; but I think you can see that the problem is that of how we can say that something which is a cause (philosophically, the Supreme Being is known as the cause of the finite universe) can be *similar* to something else (ourselves as good or intelligent), but not know *in what respect* it is "partly the same and partly different."

And this is just what the notion above of analogy explains, arising naturally out of an analysis of effect and cause. So it looks as if our theory is on the right track; we have been able to solve a conundrum thousands of years old while we were accounting for why scientists are looking for what makes sense out of their data.

2.3.2. An important point

Now then, let me make the important point I promised a few pages ago:

● **IMPORTANT POINT: Causes are *not similar* to their effects.**

In general, a cause will be *very different* from its effect, because it is a fact *not in* the effect as such. So these theorems about identical effects and identical causes and similar effects and analogous causes mean that when the effects are *identical or similar among themselves*, the causes will be identical or similar among *them*selves, ***not** that they will be "like" their effects **in any way**.*

This idea that the cause is like the effect came about because very often *causers* are like their *affected objects*, and philosophy and science has often foundered on the rock of confusion of cause and causer and effect and affected object.

That is, dogs are called the "causes" of puppies, which grow up into dogs; and cats are the "causes" of cats, and guppies of guppies.

But these aren't causes; they're *causers.* Why a *dog* begins to exist rather than a cat, for instance, is explained by the *configuration of the genetic molecules* that get into its initial cell; and this is the cause of the conception of a dog. Now it is true that this particular set of genetic molecules came from a dog, not anything else; but the *cause* of the molecules' being this way is the *mechanism by which the living body builds molecules of this type* and this in turn is caused by a *complex of several genes in the parent dog's genetic molecules.*

But this isn't at all like a doggie; so the cause of a doggie is actually *a certain complex **activity** of—to be sure—(two, not one) dogs*; but the point is that the cause **isn't** the dogs themselves.

● **In order to do science, and in order to understand what science is doing, you have to learn to think *abstractly.***

If you let yourself think in terms of concrete objects when investigating effects and their causes, you'll come to all kinds of silly and unwarranted conclusions. Causes are *abstract aspects* of things, and so are effects.

2.4. The leap into the unobserved

We are now in a position to explain why science, which seems so tied down to observable data, talks about unobserved things like dinosaurs (which no one has ever seen), the early state of the earth (which obviously has not been observed), electrons (which are too small to observe), the unconscious mind (which, if it is unconscious can't be observed by anyone; not the person who has it, nor anyone else—since we can't even observe anyone else's consciousness).

So scientists talk with great confidence, not only about what hasn't been observed, but about what can't (now) be observed, and even what can't be observed in principle. But how can they do this?

The answer should be pretty obvious, if our theory about science is true:

- **If it can be shown that the cause of some effect has to be something unobserved or even unobservable, the scientist knows, even without observing it, that it is a fact.**

Why? Because otherwise there is a real contradiction and things aren't the way they really are.

For instance, suppose there weren't any animals like the dinosaurs. Then how could you explain those fossil bones we see in ancient lakebeds and riverbeds? They belong to no observed animal; but the theory that little men from Mars came down and buried bones they made in their bone-factory just to play a joke on us when we dug them up would take the edge right off Occam's razor, it would need so much trimming. No, there **have** to have been animals whose skeletons these bones are; and whether we actually dig one up with flesh on it or not, we *know* that they once roamed the earth.

Similarly, if we don't have unconscious minds, where we do things because of mental operations (i.e. activities of our brain) we are not consciously aware of, then you have to assume that all neurotics are liars—and liars who are spending upwards of fifty dollars an hour to get cured of what is just deception on their part. And that theory is worse.

. . . And so on. Scientists, for all their protestations of "sticking to the observed facts" are very glib in talking about things *as facts* that they couldn't possibly have observed; and the reason they're so confident that they're talking about facts is simply that they *will not accept* a real contradiction as occurring, and they are convinced that one would have occurred if their unobservable cause doesn't really exist.

2.4.1. Operational definitions

So our hypothesis about effects and causes has enabled us to give a simple explanation of something that contemporary philosophers of science have stood on their heads trying to account for.

Since they don't want to talk about effects and causes, or admit that scientists are actually asserting the *existence* of unobservable "entities" like electrons or forces of gravity or space-time warps, they have tried to account for these "unobservables" as simply collections of observable facts.

P. W. Bridgman, in fact, coined the phrase "operational definition" as a kind of way you could define a "mental construct" (an electron, for instance) in terms of *what you did* in dealing with these things.

It goes something like this: "Electron" means "Set up your Van de Graf generator, put a photographic plate in a certain position, put a positive charge beside it, turn on the current, take out the plate and develop it and you will find little curly lines on the plate veering off toward the positive charge."

2.4.1. Operational definitions

That is, the set of operations which are supposed to indicate that an electron was actually "lurking there behind the scenes" is actually the *definition* of the term "electron." There aren't actually any electrons; only that set of operations.

Come now, Mr. Bridgman. If that photographic plate was blank when you put it in the machine, and then when you developed it it had little marks on it, *mental constructs* don't scratch photographic plates. Nor do "definitions of things that don't really exist." Something other than a mental construct had to put those marks there; and if we can't see it, it has to be something *real, and capable of marking photographic plates*, and marking them in this way.

So Mr. Bridgman's little device doesn't do the job he wants it to do; the world makes more nonsense by his view than it did with the "unobservable entities" that he wanted to replace by it. And later philosophers have shown that if you want to replace these "theoretical entities" with observed operations, you would need an infinity of operations to define any one of them.

Nevertheless, his way of definining things, stripped of its silliness, can be very useful.

DEFINITION: An *operational* or *causal definition* of something is a definition of the cause of some particular effect as "the whatever-it-is-that-causes-this-effect."

So you can define an electron, if you want to as the "whatever-it-is that causes marks of a certain type on photographic plates when put into Van de Graf generators in a certain way."

Or you could define a "dinosaur" as "whatever it is that accounts for these bones." Or the unconscious mind as "whatever accounts for behavior that a person does but chooses not to do." And so on.

We may not know *what* it is—as we saw that we don't know what makes bodies fall—but we do know that, whatever it is, it has to have all the properties necessary to explain the effect; and so, even though we don't know what it is, we can often say a good deal *about* it.

So when Sir Isaac Newton said he "made no guesses" about what gravity (his "force") was, this didn't mean either that he didn't think there was such a thing, or that he didn't know what he was talking about. Gravity is the "whatever it is that causes bodies to fall" and all he knew about it was the properties it had to have to do this job.

Operational definitions, then, are very useful in science, in spite of the fact that the theory that gave them their name makes no sense. And our theory explains why this is so. So I think it is legitimate to keep the term.

2.5. Causality We have a couple more implications about causes before we resume our look at what scientists are doing as they try to find the cause among the many explanations that might be true but aren't.

DEFINITION: *Causality* is the *relation* between the cause and its effect. It is the way in which the cause makes sense out of the effect.

Generally speaking in the real world, the cause is some activity; and it makes sense out of the effect by doing something **to** it; this *action of* the cause *on* the effect is the cause's *causality.* (It is what the cause is doing **to** the effect, as opposed to what it is in itself.)

Thus, the gravitational field of the moon is the *cause* of the falling of the hammer and the feather; but it is there whether there is a hammer or a feather to be acted on by it or not. The *force* this energy-field *exerts on* the hammer and the feather is the *causality* of the field on the objects in question.

DEFINITION: Being affected is the *relation* between the *effect and the cause*. It is the same as the causality, but looked at in the other direction.

That is, the causality is what the cause *is doing* to the affected object; the being-affected is *what is being done* to the affected object by the cause. Causality looks at the relation as from cause to effect; being-affected looks at the relation as from effect to cause (passively, not actively). But it is the same relation in both cases. As Aristotle noted long ago in this context, "The road from Athens to Thebes is the same road as the road from Thebes to Athens."

Let us make a little scheme showing causer, cause, causality, affected object, effect, and being-affected, taking the hammer as it falls to the moon as our objects.

The hammer is the affected object ; the hammer *as* falling at the same speed as the feather is the *effect*.

The *moon* is the *causer*; the moon's gravitational field (the moon as attractive to things like hammers) is the *cause*.

The moon's field *as pulling* the hammer at a certain speed is the *causality* of the moon on the hammer.

The hammer as *being pulled* in the field (i.e. the motion as being caused by the field) is the *being-affected*.

If it is hard to know what the cause is from the effect, it is in general considerably harder to know just exactly what the causality is. That is, we may be able to zero in pretty well on the characteristics of the moon and the earth that are necessary to account for bodies' falling toward them; but *how* the gravitational field attracts objects through their masses, or *what it does to them* is a mystery to us. We know the moon does *something* to objects to make them fall; but no one really knows what it really does.

2.5.1. Another important point This discussion of causality uncovers another peculiar fact about the cause in its relation to the effect; and leads us to make another important point.

● The cause is not affected by the fact that it is having an effect on something.

The way we have defined cause, it would be impossible for it to be altered by the fact that it is the cause of some effect. As cause (not causer) it is simply a fact: the one not observed, which (because it is not observed) allows the effect to appear as a contradiction. So it just is what it is.

And this actually can be seen from experience. Suppose you are in your car, and you hear on the radio a news report that a certain house (which you recognize is yours) is on fire. You swerve the car round and rush back home.

Obviously, the cause of the fact that you suddenly changed direction is *the words the news broadcaster said*. But clearly, if you did not have the radio on, you would not have changed direction; yet the broadcaster would have said those words whether you had the radio on or not. The reality which is the cause (the activity) is the same whether it is actually having an effect or not; it is just that, if it isn't acting **on** something, you can **call** it the cause of this effect (because there's no effect).

Similarly, what is needed to pull the hammer down to the moon at the speed it falls is a gravitational field of the moon of a certain definite potential (strength) at the point where the hammer is. But the moon has that potential at that point whether there is a hammer to be pulled down or not. So the *cause as such* is what it is whether there is an an effect or not.

Well, but what of Newton's Third Law of Motion: "For every action there is an equal and opposite reaction"? This deals with *causers and affected objects* (if they are bodies), not (even bodily) caus**es**. For instance, the hammer *does have* a gravitational field of its own, which is acting on the moon, and therefore pulling the moon (to an infinitesimal degree) toward it. And in general, in the physical world, whenever a causer exerts causality on an affected object, it does so through a form of energy which the affected object also has; and so the affected object is also exerting causality on the causer.

But all this means is that in one causer-affected-object pair, you generally have a *cause* in *each* object and an effect in each one. Very often, however, one of the objects is so much greater than the other as cause that we tend to call it the "cause" (in that usual sense) and ignore the causality going the other way. Thus, you ignore the fact that when you walk, you are pushing the earth backwards a little bit; what you notice is that it doesn't go far as you exert backward causality on it (and for practical purposes doesn't move at all); and so it resists your backward push, making you move forward.

I don't know if you are aware of this, but according to the General Theory of Relativity it is as legitimate in theory to consider the earth at rest and the sun moving about it as it is to consider that we are moving about the sun. Why don't we do it, then? Because the sun is millions of times more massive than the earth, and it makes more sense to consider it to be the body "about which" the other moves—just as it makes more sense to consider yourself as moving over the face of the earth as you walk than to think of walking as pushing the earth out from under you.

So Newton's laws don't contradict this notion that the cause (not the causer but the cause) is not affected by the fact that it is a cause. And this leads us to say the following:

● **The relation of *causality* is *not* a real relation; but the relation of being-affected is a real relation.**

That is, the relation between cause and effect is really a one-way relation; and it is *from effect to cause*, not the other way round. The *effect* is really different because there is a cause; but the cause is what it is whether the effect is there or not. The effect could not exist if there weren't a cause; but the cause can exist (as a reality, though you couldn't call it a cause) without the effect.

For instance, the hammer couldn't fall without the moon's gravitational field; but the moon's gravitational field is what it is without any hammer in it. Hence, the falling (the being pulled down or being-affected) is the real relation; the pulling (the causality) is what is called a "mental relation with a foundation in reality."

Aristotle called "teaching" the relation between the teacher and the student (or the teacher's words and what is going on in the student's head); and he said that there is no teaching unless there is learning. That is, if the teacher is lecturing and none of the students is learning, then the teacher isn't teaching, he's just talking. So teaching as a causality *exists in* the student, and is the *change in the student which is due to the teacher's words.* But this is really the *being-affected* (i.e. the effect—the change—**as** due to these particular words—the cause). But the teacher often does not even know whether he is teaching or not, so much is this relation between teacher and student one-way.

2.6. Condition One final piece of the theory of cause and we can get back to science. We often talk about the "conditions" under which a given cause operations. What are we referring to? In general, a

2.6. Condition

condition means that if it's present, the cause can have its effect; if it's absent, the cause can't. For instance, a condition for seeing pictures on a screen is film in the projector; otherwise, you just see light.

DEFINITION: A *condition* is a cause of a cause.

That is, if you take a given effect, it may very well be that its cause will only operate **if** something else happens; so the cause is impossible as cause unless this other something happens. But that means that this cause is itself the effect of the other event; and so from the point of view of the original effect, that more remote cause (which makes the immediate cause possible) is a *condition* of the effect.

Let us say that you hear scratching noises in the wall of your house. Walls don't scratch themselves, and so this is an effect; something in the wall is making the noise. You open the wall and find a squirrel. The squirrel is the *causer* of the noise, its claws as hard and the wood as hard are the *cause* of the noise.

But of course, the squirrel's claws couldn't make noises on the wood if the squirrel weren't there; but squirrels don't grow inside walls; so how did it get there? It fell through a hole in the roof, say. So the hole is the causer of *this* effect, and the presence of the squirrel at the hole and the gravitational field of the earth is the cause. From the squirrel's point of view, this situation is the cause; from the point of view of you listening to the noise, it is the condition for your hearing a noise.

• NOTE that you don't have to go back through the conditions (let alone all of them) in order to make sense out of the effect.

The problem of what explains the noise in the wall is solved as soon as you find the squirrel; supposing it to be there, moving its claws on the wood, and the noise makes sense—the wall did not indeed scratch itself.

The fact that this "solution" is itself problematic is not really relevant to the effect as such; the cause is a *fact*, and once discovered, explains the effect. If it needs explaining, it is nonetheless a fact, and it is **as** a fact that it does this job.

Of course, you *can*, if you want to, pursue the conditions for a given effect as far back as you like—from how the squirrel got there to how the hole got in the roof, to how the stone that made the hole got up so high that it could fall through, to how the planet blew up that made the stone which fell from the sky as a meteorite, to how that planet got formed in the first place, to how the star that was the Sun's companion blew up, to how that star got formed, to how the hydrogen cloud the stars formed got there, to how the Big Bang took place that the cloud formed from—to, I suppose, God; where you have to stop, for reasons I don't want to go into (God would be the "ultimate cause" and is the ultimate condition for anything).

But the point is that how far back you go into the conditions for a given effect is up to your own curiosity; your effect is explained as soon as you find the fact that is the cause; and that fact is a fact *somehow;* either by itself or by means of some cause, which itself is self-explanatory (and so is not an effect) or is the effect of a more remote condition.

● **NOTE that *all* the conditions for a given effect *must necessarily be fulfilled.***

This is obviously true. If a cause is necessary for the effect to exist, and if a condition is the cause of a cause, then if some condition were not a fact (were not fulfilled), the effect would not occur—because its cause could not exist; and in that case, it couldn't exist itself.

Hence, you know that, however it may happen, the conditions are fulfilled all the way back to the ultimate condition (Yes, there always is an ultimate condition, but I am not going to discuss why, because it would take about sixteen pages to prove it, and the point isn't that important here). So you may act on that assumption and stop when you stop being curious any more.

So if scientists don't pursue some of their investigations back to God, we don't have to fault them for stopping short of going as far as it is possible to go. If they're not that curious, then that's all right. But what satisfies them may not satisfy others—and just because they feel comfortable stopping where they stop, it doesn't mean that people who find their causes problematic are somehow "not scientific" or "want to wander off into mythology."

I seem on the verge of making a prediction from this view of science. But let me hold off on it, and let us get back to scientific procedure.

CHAPTER 3

THE QUEST FOR THE CAUSE

3.1. Third step: experiment

Given that the scientist cannot logically prove his hypothesis to be the one that actually states the cause, and given that the logic of the situation only allows for falsification (by showing that some fact or other is left unaccounted for by the hypothesis) we would expect scientific method from this point on to be a series of attempts to falsify various hypotheses, so that they could be eliminated—with the hope of eliminating all but one, and so coming to Sherlock Holmes' famous statement, "When you have eliminated all other possibilities, my dear Watson, the one remaining, however improbable, must be the truth."

And, in fact, that is what scientific method does. First, it checks to see if the hypothesis in question does in fact explain all the data that were originally observed; if not, then there is a piece of the world that this hypothesis leaves contradictory, which means that it can't be the true explanation of the effect. This is the "experiment" stage of scientific investigation.

3.1. Third step: experiment

DEFINITION: A scientific *experiment* is a procedure set up to determine if the hypothesis actually does explain the effect as observed.

What is done here, usually, is to vary aspects of of the affected object and the supposed "causer" (whatever it is that contains what is hypothesized to be the cause), in order to find out whether the causality still "works."

This is a kind of concrete attempt at abstraction, so to speak. You can't actually *remove* the effect from the affected object, or the cause from the causer; but if you vary the situation, changing what you suppose to be irrelevant aspects of it, then the *sum* of the experiments will leave constant only the various aspects you thought to be involved in the effect and cause. You can then find out if the aspects of the "cause" still make the effect what it is.

This is a little harder to describe abstractly than it works out to be in practice.

Suppose you notice that people breathe faster after they have been running, and you are curious as to what running has to do with breathing, since you use your legs for running, not your lungs. Well, of course, you know that you burn energy when you run, and also, the cells in your body get filled with the waste products of energy. You also know that breathing supplies oxygen to the blood (which is what is used in burning, even in the body), and, as you breathe out, removes carbon dioxide from the blood (which is a waste product). But is it that when you run you need more oxygen, or when you run you need to get rid of more waste, or both?

The best guess is, of course, that it is both. But let us say that you make as your first hypothesis that the body needs more oxygen from the lungs. To test this, you put a person on a treadmill and let him run, and watch his rate of breathing after fifteen minutes. You let him rest and do this several times so that you have a good idea of what happens to his rate of breathing normally after fifteen minutes of running. Then you make him run for fifteen minutes with an oxygen mask on, breathing pure oxygen. If afterwards, he breathes just as fast as he did without the mask on, then it can't be that he's breathing faster because he needs more oxygen—in which case, the *sole* cause of breathing faster is getting rid of the waste accumulated from the running. You have falsified your hypothesis.

If, on the other hand, he breathes after this experiment at the same rate he breathed when resting, then you have by implication eliminated the hypothesis that the faster breathing had do do with a faster elimination of built-up waste in the blood; all he needed was more oxygen, which he got during the running by the oxygen mask.

If he breathes somewhat faster than normal, but not as fast as he did when not supplied with extra oxygen, then your original guess was probably on the right track; he evidently needed more oxygen, since, getting it, there was a "component" of his breathing faster which was accounted for in the slower "fast breathing"; but he needed more than just to *receive* oxygen, because he still *did* breathe somewhat faster afterwards.

Of course, in this case, it is still possible that he needs so much oxygen that it can't be supplied even if he breathes pure oxygen when running. So now you will have to devise another experiment which will vary the ability to eliminate carbon dioxide, to see if that enters into the situation or not.

And so on. But all of these ingenious devices are simply to test whether the hypothesis does explain the effect you originally observed. As is obvious, if the effect is at all complicated, this stage of investigation can take decades.

But when all is said and done, what has really been accomplished with a successful set of experiments is that *it is not proved that the hypothesis is **false***. There still are an infinity of explanations that could be true.

For example, it might be that the faster breathing is really a kind of reflex connected with strenuous motions of the legs, the way a bird's neck bobs forward when it walks; and while it is at it, this happens to supply extra oxygen to the muscles, which happen to be what is needed because of the strenuous exertion. It doesn't sound very likely, but it has to be eliminated, somehow.

And this sort of thing can be very significant. The tobacco companies, for instance, are putting forward the hypothesis that the greater incidence of lung cancer found among smokers is due not to the smoking, but to the fact that people who are prone to lung cancer happen to be more inclined to smoke than people who aren't. That is, the lung cancer, they say, isn't caused by the smoking, but *both* the lung cancer *and* the desire to smoke are (independent) *effects* of some cause in the metabolism or genetic makeup of the smoker (or lung cancer victim). Not a likely hypothesis—but again, one which must be eliminated somehow for it to be proved that smoking causes lung cancer.

3.1.1. Speculation So we haven't really proved anything, even with a successful set of experiments. We just have reason to believe that . . . We have an explanation that does explain the data we observed, but is not the only possible explanation, and so might not be the true one.

DEFINITION: *Speculation* is the discovering of an explanation for a given effect.

DEFINITION: Speculation is *scientific speculation* if the explanation is checked to see that it is (a) internally consistent, and (b) that it does indeed explain all the observed details of the

effect.

Pure speculation or "airy speculation" doesn't bother to do any checking at all; it just comes up with something that "stands to reason." It says, "The cause of teen-age pregnancy is that there's not enough education about contraception." This would imply, of course, that those who knew about contraception wouldn't get pregnant; but the pure speculator doesn't bother to find out if this is the case, since it "stands to reason" that the explanation of why teenagers get pregnant is that they don't know how to avoid it. But of course, they might also want to get pregnant (for instance to tie the boy to them as the father, or even to have a child by him whether tied or not), or they might get pregnant because "decent girls" don't *plan* to have sex next Monday night, and so they don't take the Pill until it's too late for it to work—and so on.

This kind of thing goes on all the time; but it's not scientific. The pure speculator finds an explanation that satisfies his mind; and from then on, don't bother him with facts, because he's satisfied himself. If his explanation doesn't explain all the data, it explains enough of it to put his curiosity at rest, and he considers the scientists, who say, "Well, yes, but might it not also be that . . ." to be kooks who like to waste their time belaboring the obvious.

That there might be something to say for the scientific type of curiosity that isn't satisfied with any old explanation can be seen from the example above of teen-age pregnancy. Suppose ignorance is only one factor in the problem, and not the most important one at that. The speculators above will now spend lots of money establishing "pregnancy-avoidance clinics" in schools and so on, where they will make contraceptive information and contraceptives available to teen agers.

Suppose, however, the major factor in the problem is that teenagers get the idea that it's not really a good thing to have sex whenever you feel like it, and so sleeping around is not "really right." These clinics, however, say that there's nothing really so terrible about sleeping around; it's getting pregnant that's the disaster. Then the kids are pulled in two directions: don't do it anyway; but it's really okay as long as you don't get pregnant. This means that the ones who want to do the right thing, and who consider themselves as "decent" will not take the precautions which imply that they're actually planning to be promiscuous; and so they'll go out on dates without protection. But when they get alone together, and the sexual urge gets strong, the other side of the equation of "there's nothing really bad about this" will influence them and they'll have sex—in a situation where they're likely to get pregnant.

But if this is an important explanation of teen-age pregnancy, then "pregnancy avoidance clinics" (based on what "stands to reason") are actually calculated to *increase* teen pregnancy, not decrease it.

Tell this, however, to the speculators, and they will shout you down as "restricting reproductive freedom" or something.

The point here, of course, is that it isn't just the scientist who finds explanations; we all do. The difference is that the scientist wants to find the cause; and we assume that any satisfying explanation is the "cause."

3.1.2. Thought experiments

Sometimes it is not possible actually to perform experiments, because the conditions under which they would have to be done are so extreme as to rule them out. In these cases, scientists sometimes resort to a kind of speculation called a "thought experiment" or a "gedanken experiment" (from the German word for what is thought).

Here, the known properties of what you are working with are "extrapolated" (carried farther than observed) into the conditions under which the experiment would take place, and then, based on what you know from observation and can assume from your extrapolation, you consider what the objects *would probably be doing* in these conditions, provided you could get them there. If they result in the observed data, then this is taken to be *some* indication that your hypothesis is not false; and if they don't, then this is again *more than a hint* that something is wrong with it—but often not much more than a hint.

The problem is that the behavior of things doesn't necessarily follow your extrapolation. For instance, as you lower temperature of electrically conducting materials, the degree to which they conduct electricity decreases (i.e. their resistance increases). You would therefore suppose that at very low temperatures, electrical resistance would be extremely high. But once people were able to get extremely low temperatures (close to "absolute zero"), it was found that certain metals and so on became "superconducting," as if their resistance dropped almost to zero.

Any thought-experiment, then, based on extrapolation of the tendency of materials to resist current based on temperature would be wildly off the mark. And this sort of thing is always possible. Hence, thought-experiments have to be (and usually are) taken with a large grain of salt. But if nothing better is available, they can be useful.

6.2. Science and mathematics

Of course, as I mentioned, when the scientist gets through his experiment, he's still only in speculation, though it's better speculation than the ordinary person's. But before we go on to a further step in the search for the cause, let us pause and consider why measurement and mathematics play such a heavy role in scientific investigation.

● **Measurement is important in science because, (a) if the objects can be measured, then this is an aspect of them which may enter**

6.2. Science and mathematics

into the effect and the cause; and (b) even in other cases, measurement can allow finer variations than mere qualitative ones.

In the example of teen pregnancy above, for instance, you can't *measure* attitudes. But you could take polls (if you're careful) among teens who got pregnant to find out what percentage of them knew anything about contraception.

The actual percentage is not terribly significant in itself; but if, say, only ten percent of them knew what you were talking about when you mentioned contraceptives, then the "ignorance" hypothesis is much stronger than if half or two thirds of them knew about it. It isn't the numbers themselves which do the job, but the numbers allow you to have a control over something which otherwise is apt to slip into the "it stands to reason" category.

Measurement, however, can become a fetish which actually *gets in the way* of scientific investigation. It sometimes is the case that numerical results that mean nothing are taken as "fact" because they are numerical.

For instance, one college I know once had students rate faculty on various aspects of teaching performance. The scale was one to five, from "bad" to "good," with three being "average." All of the answers were then added up for each professor and divided by the number of questions, so that the professor got an "average" evaluation from each student. Say, one student's "average" came out to 3.6. Then each student's "average evaluation" was "averaged" with the other students', so that the professor got an "average evaluation" of the class as a whole; say, 4.2. Then *this* average was averaged in with the average average of his other classes; so that the professor's "final average evaluation" of the semester turned out to be 4.1, say—meaning that the "average student" he had that semester, if he had answered all of the questions with the same number, would have given him a 4.1, which is a little to the "excellent" side of "good."

Then this average was *compared* with the averages the other professors got in this same semester, and the "average average average average" for all the professors (Jones got 4.1, Smith got 4.3, Doe got 4.0, etc; the average coming out to, say, 4.2) was arrived. at.

Our professor is now compared with this "average professor's average average), and it turns out that with his 4.1 he is *below* it; and *it is now "scientifically concluded" that* ***he is a below average teacher.*** This in spite of the fact that his students' evaluation of him was to the excellent side of good—definitely above average.

Here you have the manipulation of numbers leading you into a never-never land where the conclusion directly contradicts any meaning the original data had. They were subjective evaluations in the first place, and they are supposed to give you some kind of "objectivity" because you attached numbers to them (this is false). Then, once you have the numbers, you can manipulate them in all sorts of interesting ways; but the manipulation has nothing to do with anything that the original "measurements" corresponded to; and the "objective conclusion" you come up with is simply a wild flight of fancy.

IQ tests are notorious for this. Stephen Jay Gould has written a whole book called *The Mismeasure of Man* which shows what a mess you can get into when you take numbers, however arrived at, as "objective" and "factual," especially with things like IQ tests.

There is a good deal of airy speculation that involves numbers, in other words, and has nothing to do with true science.

● **Numbers are not magic. Not everything has to be in terms of numbers to be scientific, and not everything that involves**

numbers—even complicated uses of numbers—is scientific.

3.2.1. The logic of mathematics

The other reason why mathematics is useful in science is connected with the silly conclusions drawn in the evaluative process above. Mathematics allows one to manipulate numbers logically; and when these numbers represent a real aspect of something, then the logic of mathematics can sometimes reveal the way things behave.

There is also the fact that mathematics is a kind of logic that allows for "inverse operations," so that mathematical problems can be worked in opposite directions. That is, the inverse operation of 2 + 2 = 4 is 4 - 2 = 2; the inverse operation of 3 x 2 = 6 is 6/2 = 3, and so on. You can take the answer of one operation, perform the reverse operation with it, and get back one of the original premises.

This is very handy in science, because you are starting with the effect, which, as I said, is the "then" clause of the "if-then" statement—or, if you will, is the "answer" to your explanatory statement. If you couch your "if-then" statement in mathematical terms, then, it is sometimes possible to arrive at the cause by using the proper inverse operation. You may not know much about it; but you've got a track to use to find it.

For instance, the calculus starts with a derivative: dx/dy = some function. Antiderivation (which is not the same as integration, for reasons we don't have to explore here) will give you a whole family of equations whose derivatives are all the one in question. This sounds very like the infinity of explanations for a given effect—and not surprisingly so. But what you learn with this family of equations is that they all have certain properties in common and differ only in what is called the "constant of integration." And if you integrate over a certain range, you get a "definite integral" which tells you what was going on in an interval within which you observed your effect.

Interestingly, the calculus was simultaneously (and independently) invented by Gottfied Leibniz, who was interested in it for mathematical and metaphysical reasons, and Isaac Newton, who needed it for solutions to physical problems. Mathematicians are not really terribly concerned with the applications in science, but only in the logic involved; but for scientists, problems of the consistency of the mathematics are secondary to the fact that it works—and it works not only from cause to effect, but from effect to cause.

3.2.2. Probability and statistics

But let us look at one mathematical tool and investigate why it works—because it looks on the face of it as if it shouldn't; but it is very useful in science. And it turns out that we can perform a couple of thought experiments and show that our own theory of science forms the best explanation of why it works. I am referring to the mathematics of probability, and especially to its inverse operation: statistics.

The effect here is **how there can be laws of probability.** A **law** indicates a **constant, non-random** relationship; but probability deals with objects that behave **randomly.** How can randomness be non-random?

There are several explanations, two of which we will test as hypotheses, using a die (one of a pair of dice—one for simplicity) as an object for thought-experiments.

● **First hypothesis: The laws of probability indicate that what you thought was behaving randomly actually wasn't.**

This would mean that when you throw the die, the operation of the laws of probability indicates that you *thought* that you were throwing the die randomly, but you really weren't.

We can test this by giving you a loaded die. Here we know that one side of the die is favored so that it winds up on the bottom, making it not completely random which side will end up there.

But in this case (let us say the die is weighted so that the four is comes out on top), the four comes out *more often* than you would expect from the laws of probability. So when the throws *aren't* random, then the laws don't work. Hence, there *must* be randomness for the laws to operate, and this hypothesis is ruled out.

● **Second hypothesis: The non-randomness is due to the constant underlying structure of what operates (otherwise) randomly.**

What this hypothesis says is that the **operations themselves** are random; but the **underlying structure of what is operating** produces **constraints** on these operations, which give them a quasi-systematic character—i.e. prevents the operations from being *totally* random.

If we roll our die, for instance, we find that the laws of probability predict that the four will come out on top one-sixth of the time—and there are six faces to the die. If we flip a coin, heads is predicted half the time—and there are two sides to the coin. This suggests that the total number of sides (i.e. possibilities) and the side that comes up (the possibility which is realized) are related, and it is *the fact that the total number of possibilities remains constant* that makes the laws work.

Let us now perform a thought-experiment. Let us make a die out of soft clay or something which will be deformed when it hits the table as we roll it. We form it into a die and put the spots on it; but each time we roll it, it gets a new "face" when it hits the table, so that you can't predict how many faces it will wind up with on each roll—the number could vary from one (if it makes itself into a ball), to two (if it makes a lens), right up to infinity (the ball again).

Now, what percentage of the time is any spot we put on it going to come out on top? You can't predict anything. So this experiment confirms the hypothesis.

Note, however, that if you form a die (supposing you could do so—this is the neat thing about thought-experiments) that could vary randomly in **number of faces** on every throw **from three to six**, but could never be fewer than three or more than six, **you could now get a probability relation.** Not to bore you with the mathematics, the reasoning would be like this: one-fourth of the time, there will be three faces, one-fourth, four faces, one-fourth five, and one-fourth, six faces; on the one-fourth of the time there are three faces, one-third of *those* will have our special side on top; on the one-fourth when there are four faces, one-*fourth* of those will have our face on top—and so on. Multiplying these individual probabilities together will give you a number which is the probability for the face's being on top in the "real" die.

But this is consistent with the hypothesis. The fact that the underlying structure of the die makes the *variation in faces constant,* puts a *constraint* on the total number of possibilities that can be realized in the random operations, and prevents them from being absolutely random.

● **So it seems that the laws of probability *do* need random operations, but the "lawfulness" is due *not* to the randomness, but to something that prevents the randomness from being absolute.**

If you can find this constant underlying structure, you can *predict* that the random operations will not systematically vary from a given ratio between the total number of possibilities and the number of attempts at realizing one of them.

3.2.2. Probability and statistics

What do I mean "will not systematically vary"? This is a more technical way of saying "in the long run will come out to" the ratio in question. That is, there may be deviations from this ratio that are large; but they will *tend* to be "compensated for" by deviations in the other direction—but *not* in any *systematic* way. Thus, if you flip a coin, you might get twenty heads in a row; but as you keep flipping, you will find that you get more tails than heads, until the total number of times heads comes up (as the number of flips becomes very large) approaches half the number of throws.

This, by the way, is *not* mathematically necessary. All the mathematics **says,** (taking the die as an example) is that there is no greater likelihood of the four coming on top than any of the other six faces; and this ratio one side to the total is one out of six. It then *suggests* that, **since** there isn't a greater likelihood, then there *might be a parallel ratio between* ***the number of times the four comes up and the number of rolls.***

But there is no *reason* why this second ratio would *have* to be the case if the first one is—no mathematical or logical reason, that is. There is nothing *logically to prevent* its being the case that the rolls be totally random (not converging on any ratio at all, the way our soft die behaved). It "stands to reason" that the ratio would appear; but it isn't proved by that that it would have to. True, no other ratio would be logically allowed; but total randomness is not excluded by the mathematics itself.

It turns out, however, that *experiments with actual objects tend to verify this prediction,* and hence, we can say that the theory we have above explains a constancy in otherwise random operations. So probability is not actually a "mathematical" law at all; it is an *empirical* law that has a mathematical foundation—there is nothing, in other words, in the mathematics itself that says it *has* to work out in the real world; but we investigate and find that it just does.

The reason I stress this is that some think that the laws of probability are "purely mathematical" and work for that reason. But there are others who think that what "stands to reason" has to work out in practice. Both are wrong.

The so-called "law of averages" shows the latter fallacy. This is what happens when you're flipping a coin and you've got a long string of heads—say, heads has come up twenty times in a row. Would you bet on heads the next time? Well, it's very unlikely that heads would come up twenty-one times in a row; the "law of averages" says that tails has to start coming up soon to make up for the twenty heads you got in a row. So it's more likely that you'll get tails this time than heads, right?

Wrong. There is a fifty-fifty chance that you'll get heads just as on any flip. Why? (a) The coin doesn't know that twenty heads have come up. "Yes, you say, but twenty-one heads in a row is much more unlikely than even twenty." (b) But *given* the (very unlikely) event of twenty, then the mathematics of the laws of probability works out that it is *now* just as likely that there will be twenty-one as that the run will stop at twenty.

The laws of probability state that it is very unlikely that twenty-one heads will come up in a row; even more unlikely than that twenty will. The "law of averages" says that it "stands to reason" that if twenty **have** come up, it is more likely that tails will come up the twenty-first time. Both laws "stand to reason" and neither says what **has** to be the case; but the laws of probability do describe what goes on in the real world and the "law of averages" doesn't.

What then have we done?

● **The "constant underlying structure" is the *cause* explaining why the laws of probability work.**

3.2.2.1. Statistics But now let us briefly look at statistics. These are probability worked backwards: its "inverse operation." What

3.2.2.1. Statistics

happens is that a person notices a ratio that *looks like* a probability ratio in what otherwise seems random; he then hypothesizes that there is some “constant underlying structure” and goes looking for it. If he finds one, he then says that the statistics are “valid” and makes predictions on the future behavior.

For instance, a scientist notices that teen agers have more automobile accidents that married middle-age men, say. Is this greater number of accidents per number of miles driven just an accident (pure randomness) or is there something in the **nature** of the teen ager as opposed to the middle-aged driver that would explain it?

Well, teen agers have quicker reflexes (which if anything would argue against more accidents), but are more apt to try to test them, and are less apt to be aware than actions sometimes have irrevocable consequences. These last two characteristics of teen agers would lead you to expect them to be more reckless when driving, and so to get into more accidents. Hence, the statistics are probably valid; there does seem to be a “constant underlying structure” putting constraints on what otherwise would be random.

Similarly with smoking and lung cancer. The “tar” in tobacco smoke, when isolated, is clearly toxic, and when injected into animals results in increased cancers. You would therefore **expect** that taking this stuff into your lungs would cause damage, and specifically lung cancer. But smokers do get more lung cancer than non-smokers; and hence the statistics are valid, and the tobacco-company hypothesis (that both are effects of a more remote cause) is a smoke screen.

The reason some statistics are valid and some aren’t is that probability-like ratios **can** occur by chance, where there are no underlying constraints. For instance, the statistical ratios of “average evaluations” of the professors I mentioned a while back is simply a number which a little thought will show does not reveal how good the teacher "really is" as if this were the constant underlying structure which gave rise to the ratio, or even how good the teacher was really "thought to be" by the students.

In fact, I once did a study of some two hundred evaluations (confirmed by other studies) and I found a very strong correlation between the grade the student expected and how highly he ranked the professor (in almost any area you want to name—such as "sense of humor"). Now it "stands to reason" that a student who expects to get a good grade in a course is going to think the teacher is pretty good (even if he finds the course boring), and one who expects to fail is going to blame the teacher, not himself. And so, given the psychology of the student, you would expect this correlation, whether the teacher is actually any good or not. And it occurs.

The point is that (a) a ratio might be just chance—after all, if there are two numbers that can be set into relation with each other, they have to come out to *some* ratio; and (b) that it might indicate a constant underlying structure that is very different from the superficially obvious one.

To find this latter, you would have to perform experiments, varying what they call the "parameters" (the things that can vary, some of which might not make a difference) and seeing which things affect the results and which don't. Only then do you have some hope that your statistics are valid.

● **So statistics reveal a constant underlying structure which forms the cause of the observed ratio.**

● **NOTE that this means that things that are describable statistically are so describably *not* because of "chance" but because of the *nature* of the thing operating.**

The "nature," of course, is the "constant underlying structure." So when statisticians find things about teen agers and accidents, they do so on the basis of the nature of teen agers; when the Surgeon general gives statistics about smoking and lung cancer, he has revealed something of the nature of smoking, and so on. These things *don't* deal with the *random* aspect of what is operating; they focus on its *non-random element*.

Hence, our theory of effect and cause can explain a good deal about probability and statistics. It sounds as if we have a rather powerful theory going for us.

3.3. Fourth step: theory

But this brings up the next "step" of scientific method, which isn't really a step at all, but just a name. A hypothesis that has survived the experiment stage isn't called a hypothesis any more, but a theory.

DEFINITION: A *theory* is a detailed statement of what is thought to be the cause of the effect in question.

As long as we have defined theory, and in our discussion on probability theory we were talking about the "laws" of probability, we might as well define a law.

DEFINITION: A *law* is a constant relationship that obtains in reality.

Laws are facts; relationships "out there." Now if a theory is so well verified that it is taken to be a fact, it is sometimes called a "law"; like, for instance Newton's "law of gravitation." (As a matter of fact, this "law" is false; but it was assumed until the beginning of the twentieth century to be unassailably the case.)

But law and theory don't *mean* the same thing. A law is a relationship, whether it explains anything or not, so long as it is constant. A theory always is an explanation, whether it involves a constant relationship or not.

Obviously most theories will talk about what are supposed to be constant relationships (because they explain the effects, so that there is a constant relationship such that whenever the effect occurs, the cause is there—and the theory states what it thinks the cause really is); but laws can just be observed connections.

For instance, Boyle's and Charles's laws of gases state that as temperature increases either the pressure or the volume of the gas (depending on which law) increases in a definite ratio to the increase of temperature. This was just observed as a fact. Take a gas (of a certain type), put it at the freezing point of water, raise it one degree Celsius, and you will find that if it's in an expandable container, it will expand; and if it isn't, the pressure on the container will increase by 1/252.

The kinetic-molecular *theory* of gases *explains* this law: it says that heat is motion of molecules; but if molecules are moving faster, then they will need more room to move around in, and will hit the container harder. Thus, expansion and/or pressure increase.

3.3.1. Criteria for a good theory

Now then, according to the canons of scientific method, a theory, in order to be a good one, has to be (1) simple, (2) comprehensive, and (3) logical; it is also held that unless a theory makes predictions, it really isn't much in the way of being a theory. We will discuss all of these.

3.3.1.1. Simplicity

First of all, as I mentioned, "simplicity" does not mean that the theory is easy to understand or doesn't involve complex logic; it means that the theory doesn't assert the existence of very much that can't be observed.

The reason for this (based on our theory of science) is that a theory is an *explanation* of an effect, and hence is something that *makes sense* out of what otherwise doesn't make sense. In other words, it makes reasonable what is otherwise unreasonable.

Now in discussing probability, we saw that chance doesn't *explain* anything; the only reasonableness (or "lawfulness") about probability doesn't come from the chance element, but from the constant constraints upon it. What "just happens" may be *true*, but there's nothing *satisfying to reason* in an event that's simply a fact.

Now then, if a theory states three or four or five facts, each independent of one another, as the "explanation" of the effect in question, then no one of the facts explains by itself, but *all five together* form the "real" explanation.

But if these events are *independent* of each other, then the explanation hinges upon *the fact that the five of them just happen to be operating together*. In other words, the "explanation" ultimately rests on chance—or the coincidence of the five elements.

Hence, the more elements you get in your theory, the greater the role *chance* takes in the "explanation"; but chance doesn't explain something—and so your theory is a bad theory.

Of course, if the many elements in the theory are connected by some fact, then it is this (single) *connection* among the elements that explains why they are present together; and so the connection becomes the simple fact that is the real basis of the explanation.

So it isn't because a coincidence of many factors can't *in fact* produce results that good theories have to be simple; but if they do, *there is no way to get at this coincidence by reason*. You might just as well have stopped with the effect and said, "Well, it happened somehow" for all the satisfaction your mind is going to get out of an "explanation" that "just happened."

And this is why, of course, scientists aren't really like detectives. An actual murder, for instance, very often hinges on the chance coming together of a number of independent elements, where people do improbable things because they just happened to be in an odd mood at a time when someone else just happened to say something that lit the fuse, and some passer by just happened to be someone with a very strong motive for wanting the victim dead, and had threatened him the night before, and so on—and it rained, washing away the clues; and the weapon caught in a branch as it was thrown into the stream, and on and on. To find out what actually happened in a case like this depends as much on luck as on ingenuity. Anyone who is at all intelligent and has read all but the absolutely best detective fiction can figure out a number of other ways of solving the riddle involving someone else than the author's villain.

So the romance of science is not really true; scientific theories are simple, not because the truth is simple, but because that's the only kind of thing our minds can make any progress with in making sense out of what doesn't make sense by itself.

And so our theory explains why theories are simple, but why the more complicated cause might in a given case actually be the true one—and our theory is based on the simple fact that scientists are looking for the true explanation of the effect.

3.3.1.2. Comprehensiveness Secondly, a good theory has to be comprehensive: that is, explain *all* the elements of the effect that it is supposed to be the explanation of.

This sounds trivial; and it might seem that we already saw it when we were discussing the experiment stage of the method. Any theory that leaves some facts unexplained, of course, leaves something about reality self-contradictory or impossible; and therefore, it is no explanation.

But the theory has to explain all the aspects of the *actual effect,* not just the ones that were *thought by the scientist* to be the aspects of the effect when he made his observation.

That is, there may be aspects of the effect that no one was

3.3.1.2. Comprehensiveness

aware of at the time of making the experiments and formulating the theory, and these aspects might change the whole nature of the effect (and so make the "cause" expressed in the theory not the actual cause at all).

And this has happened in science. Not the least notorious case is that of Newton's theory of universal gravitation. Newton theorized that what made bodies fall was, as I mentioned, a force that was proportional to the products of the masses and inversely proportional to the square of the distances between the bodies' centers of mass. This theory also explained why orbiting bodies stay in orbit; basically, they are falling toward the main planet, but they have such a great speed (initial tangential velocity) in a straight line that they "miss the edge" in their fall, so to speak, and fall "around" the body instead of into it.

Well, the point is that the theory explained very accurately all the motions of the planets, once you took into account that their orbits would be affected by the pulls of other planets as well as the sun. And all was rosy.

All, that is, until the beginning of this century, when extremely accurate measurements of the orbit of the planet Mercury were made. It turned out that Mercury's orbit was off from what Newton said it should be by a matter of a few seconds of arc per century. (For those who are curious, an angle of ninety degrees, drawn at the center of a circle, cuts through the circumference enclosing an arc of that circumference: an arc of ninety degrees. An angle of one second is a sixtieth of a sixtieth of a degree; so a second of arc is a very small distance indeed. I have never looked up the actual linear distance, but it might have been just a few miles from where Newton said it should have been.)

The point is, though, that this tiny discrepancy between what the theory **said** the facts had to be and what the facts actually were destroyed the theory. The force of gravity couldn't be the cause that explained why Mercury traveled round the sun.

Of course, scientists noticing this were in a quandary, and were more ready to doubt the observations than the theory—until Einstein came along with an alternative explanation (based, as I mentioned, on a warping of space-time) which accounted for the whole of the motion of Mercury as well as all that Newton could account for. Einstein's theory is comprehensive; Newton's isn't—even though Newton *thought* his theory explained all the facts, and so did everyone else for a couple of centuries.

3.3.1.3. Logic The third criterion of a good theory is that it be "logical," which means that the effect in all of its aspects should follow logically from what is stated to be the cause (i.e. *if* the cause is what it is stated to be, *then* all aspects of the effect would have to be what they are observed to be—either now or in the future). This is another triviality, from the point of view of our theory of science.

But I would like to discuss here the problem of *induction,* which is a logic used in science, and which, it seems, cannot be a logic, because it seems to violate one of the principal canons of logic. We will formulate the effect, and give several hypotheses, rejecting all but what I think is the true one—which follows from our notion of cause and effect.

3.3.1.3.1. Induction The effect connected with induction is this: First, induction cannot be a form of logic, because induction argues from observing a few instances of what something does to what **every** instance of that type of thing does—and one of the main principles of logic is that you can't argue "from the particular to the universal" (from "some" to "all").

Yet induction **has** to be a form of logic, because, when we say, for instance, that hydrogen combines with oxygen to form water, we (a) have directly observed only a few instances of hydrogen's doing this; but (b) we know that—under the proper conditions—**any** instance of hydrogen will do it. We have to "know" this by **some** kind of reasoning, because (given that hydrogen is the most plentiful element in the universe), we certainly didn't know it from observation.

There are several hypotheses that have been offered to explain this effect. Let us look at them.

●**First,** there is David Hume's solution, which is basically that we **don't** know that all instances of hydrogen combine with oxygen to form water. All we *know* is that the ones we observed have done it. But since every time we have brought hydrogen and oxygen together in the past, we got water as a result, then *we have built up a habit or expectation* of seeing it happen in the future; and so we (mistakenly) suppose that somehow it "has" to happen or that it "will" happen every time we try. but this is a supposition or a belief (or perhaps a hope), not knowledge.

This, however, is the equivalent of saying that induction is like saying, "All the living things in this room are human," because you've looked and all you see are people. But then someone shows you a spider hiding under the sofa; and you simply say, "Well, not all the living things in this room are human, then."

But if a scientist took a bottle labeled "Hydrogen" and combined it with oxygen and what he got was a green gas, he wouldn't say, "Well, not all hydrogen combines with oxygen to form water"; he would say, "That's funny; there's supposed to be hydrogen in that bottle."

That is, induction results in what has been called a "lawlike generalization," where the person who holds it *will deny observed instances that seem to violate it* before he will give it up as true.

(Lawlike generalizations, as they say, "support counterfactual instances."). The scientist will hold on to the results of his induction until the evidence against it becomes overwhelming. One or two cases will not make him give it up as false—the way a simple observation like the living things in the room will.

But this hypothesis basically puts these two kinds of general statements on the same footing, allowing no way to distinguish one from the other. But we do make the distinction.

So—sorry, Mr. Hume, but your hypothesis doesn't fit the facts you were trying to explain.

●**Second,** to account for the difference, some philosophers have said that what happens in cases like hydrogen and other "lawlike" generalizations is that, once we get to the general statement, we *define* the object we are dealing with as *"whatever-it-is-that-does-such-and-such"*; and then, obviously, anything like the object that doesn't do it falls outside the definition we made, and so isn't what we are talking about.

What I mean is this. You observe some stuff combining with oxygen to form water, and you say, "Let's call anything that combines with oxygen to form water 'hydrogen.'" Then it will *have* to be the case that all instances of hydrogen *as you defined it* will combine with oxygen to form water. If something doesn't, then it doesn't fit your definition of "hydrogen."

The trouble with this is that it will allow you to name only **one** property of the object in question. As soon as you make an induction and discover a *second* property of the same object, you can't use your "Let's call...whatever does..." any more, because you've already done this, and (a) if you *define* your object as "what does both things," you won't *know* that you've caught every instance of what does the first thing, and (b) you don't know *from observation* that the two properties will always go together. But the scientist does know this.

That is, a scientist is studying the spectrum of hydrogen (i.e. the stuff that combines with oxygen to form water). He notices that in all the cases he observes, when it burns, it produces blue lines on the spectroscope. He then concludes that "*All* cases of hydrogen have such-and-such lines in the blue region of the spectrum."

With the "definition" hypothesis, he can't know this. If he now defines "hydrogen" as "whatever has these spectral lines," how does he know that this is *also in every case* the stuff that combines with oxygen to form water? And the stuff that (based on other observations) combines with sulfur to make that gas that smells like rotten eggs? And the stuff that combines with chlorine to make hydrochloric acid? And so on.

The scientist is supremely confident that when you've got one of these properties, you've got all the rest too. But the "definition" hypothesis will explain the universality (the "allness") only for one property. So this doesn't work.

●**Third,** some philosophers have said that the "all" isn't really "all," but a probability statement. That is, the scientist observes hydrogen and oxygen combining to form water; and it works every time he tries. What his "All hydrogen combines with oxygen to form water" really means, according to this hypothesis, is "The probability is very high that any instance of hydrogen is also going to exhibit this behavior."

This sounds promising, until we look at it. Hydrogen—at least the stuff with the blue spectral lines—is, as I said, the most plentiful element in the universe. But the scientist has only *observed* as combining with oxygen (by a conservative estimate) a billion billionth of a percent of all the hydrogen there is; and he has observed this only on the earth, and in the very special conditions of the laboratory.

But you can only make a **statistical** generalization of probability when *you have observed what is known to be a representative example.* But this means (a) that it has to be a fairly hefty percentage of the total "population," and (b) that it can't be observed in special conditions, which might make the observed sample behave unrepresentatively. That is, you don't go into a Democratic party rally and ask the people there who they're going to vote for and conclude from this that the Democrat will win in a landslide, because everyone in the country is going to vote for him.

But these two conditions for using statistics to form generalizations are *precisely what are not present* with the observation of hydrogen. Hence, based on statistics and probability, we are at the Democratic rally, and it is *exceedingly UNlikely* that hydrogen combines with oxygen to form water.

So that doesn't work either.

●**What does work?** (a) The scientist observes enough instances of the behavior of some object to give him a subjective impression that the behavior isn't just chance.

How many is this? Well, if it's something like voters, whose behavior is erratic, he knows he has to observe a lot of them in varying circumstances. If it's something like hydrogen, which seems to behave the same way all the time, he doesn't think he has to observe many instances. This is all rather subjective at this stage.

(b) If the behavior isn't due to chance, then it has a—here's the word—*cause* which explains its constancy. So the scientist hypothesizes that there's a cause involved.

(c) And where would he look to find it? Obviously in the thing that's doing the constant behaving (the "constant underlying structure" again, only now it's not accounting for the lawfulness of random acts but the lawfulness of constant acts).

(d) If there is something about the structure of the object that would make it reasonable to expect the behavior (that would logically result in the behavior), then the scientist concludes

(e) That in every instance where you have an object with this structure, you will get the behavior.

...And there we are. Induction makes sense in terms of cause and effect, and in our realizing that the "nature" of the object is what explains its constant behavior.

Since the other hypotheses don't really explain induction, and since induction is *the* way the scientist gets his general statements—and so is a good part of scientific method—it sounds as if our theory of science is simple, comprehensive, and (because you would expect it to explain this aspect) logical.

There's more to induction than this, but let's leave it here.

3.4. Models

Scientists often use "models" in a theory; and so our theory of science should explain why they find them useful.

First of all, I think I should say that a "mathematical model" is not really a *model*, but a mathematical *description* of the behavior in question. It's just a statement of what is going on in terms of numbers and their interrelations, rather than in terms of words. There's really no problem here.

But describing, for instance, electrons as little pellets moving about and hitting each other, and so on **is** a model: the "particle-model" of the electron. Electrons are too small to see; but this model says that they're **like** little billiard balls.

Or then there's the "planetary model" of the atom, where the nucleus is like a complicated sun and the electrons are like little planets whizzing around it. It makes a neat picture to contemplate, but is it of any scientific use?

Some theoreticians of science say that's all a model is: a metaphor that makes things exciting, especially to the readers of Sunday supplements; but it's really not anything significant scientifically at all; it gets the scientists funded, perhaps, but no more.

Yet the particle model of the electron actually led to discoveries about the electron, and the planetary theory of the atom to discoveries about the atom, even though now there is also a wave-model for the electron (which has not displaced the particle one) and there is a "shell" model of the atom which has supplanted the old planetary one. Evidently, the models are useful.

But when you say, "John is a lion" or talk about "the smiling meadow" (meaphors), you learn nothing by *observing* John or the meadow. Where is the mane on John? Where are the teeth of the meadow? Obviously, the characteristics of the "model" in this case are no help to tell you about the thing you're wanting to learn about.

So *models are not metaphors.* Metaphors involve *emotional* similarities, so that John makes you *afraid the way a lion does* and the meadow makes you feel *the same kind of pleasure you feel when smiled at*.

● **Models are analogies.**

Here is the solution. We notice that the (unobserved) cause has *effects which are similar* to some effect of a caus**er** which we can observe. Since similar effects have analogous causes, the unobserved cause must be *similar in some unknown way* to the cause in the observed causer.

Thus, an electron's equation of motion is *similar* to the equation of motion of a dust particle in the air, say. Then an electron must be *somehow* like a dust particle, and by studying the dust particle, we *might* learn something about electrons.

But an electron's equation is **also** like the equation of the wave in a pond, in certain respects. Then an electron must be *somehow* like a wave; and by studying waves (and how they interfere with each other, for instance) we can learn about electrons—maybe.

Of course, in the world we can observed, particles can't simultaneously be waves, because waves are a disturbance of some larger body, and a particle is a little body in its own right.

But the model is only an *analogy*, and only says that the electron (as cause) is *like, somehow* the particle, and like, in other (unknown) ways the wave. Obviously, the two are somehow compatible in the electron as it exists; because an electron isn't really either a particle or a wave, but is only *really similar in an unknown way* to both.

So our theory of cause and effect, which includes analogy, explains why scientists use models, why they aren't just metaphors and why you can learn things from them, and why they aren't too terribly useful—because we don't know the precise points of identity and difference.

3.5. Last step: Verification

We finally come, in our tracing through scientific method, to what is the most important thing scientists do to separate their pursuit of the cause from speculation as to what it might be. So far, all we have seen has given us *an* explanation which is internally consistent (not self-contradictory) and which logically explains all of the data observed. But there still are an infinity of possibilities that can do this. True, we have picked the simplest of those we have been able to see; but this (as I mentioned) still doesn't mean the explanation we picked is the *true* one. How do we come closer to this goal?

3.5.1. Prediction

Scientists consider that a theory which doesn't predict anything which can then be tested is a theory which doesn't significantly differ from pure (if careful) speculation. Non-predicting theories may be the best we can do in a given case; and sometimes we have to live with them—as, for example, the theory that the universe began at a certain time some billions of years ago in an enormous explosion. We can't have conditions that would reproduce this so we could test it.

But even in these cases, the theory will generally predict *something,* and very often this "something" is open to a kind of experiment, which will see if it actually occurs or not.

Why is it that scientists are so confident that if they examine any theory hard enough, they will find hitherto unobserved facts predicted by the theory, and then can test the theory by looking to see if these indeed are facts or not?

Once again, the notion of effect and cause comes to the rescue; only this time, the solution lies in the nature of the cause, not the effect. The cause (or any explanation), you will remember, is the "if-part" of the "if-then" logical statement. We saw that, when looking from the "then" to the "if," that there are an infinity of possible "if's" that could explain the particular effect we observed.

But now, if we look at the statement the other way, it is generally the case that the "if" statement *need not logically imply* ***only*** the contents of the "then" statement. That is, the statement "If it is raining out, then the cat is in the house" is such that (supposing it to be true) the fact of it's being raining out means that it also must be true that the cat is inside. This is what is meant by "implies." But it doesn't mean that this is the *only* implication of the fact that it's raining out. The fact that it's raining out also implies that the ground is getting wet, that there are clouds overhead, that people are putting up umbrellas, etc., etc.

That is, there are *an infinity of possible* ***implications*** *for a given "if" in an "if-then" statement,* of which the "then" named is *only one*—just as there are an infinity of possible "if's" for a given "then."

●Thus, any scientific theory, which is of the form "if (cause),

then (already observed effect)" will have *other* implications beyond the already observed data.

DEFINITION: A *prediction* from a scientific theory is an as yet unovserved implication from what the theory asserts as the "cause" of the original effect.

These predictions may be of two types: The theory may predict events or "facts" not yet observed at all. Thus, Newton's theory of gravitation predicted that the rate of fall of bodies on other planets would be different from that of the earth—at a time when, obviously, no one had ever observed any other rate of fall (and it was believed no one would ever be in a position to observe one).

But secondly, the theory may predict facts that are already known to be facts, but were *not known to have any connection* with the cause alleged in the theory. Thus, Newton's theory of gravitation predicted the elliptical orbits of planets. These orbits were pretty accurately known ever since the time of Johann Kepler (Galileo even is said to have laughed at him for thinking that orbits would be anything but circular); but no one had ever thought to connect the ellipticality of orbits with the tendency of bodies to fall down when dropped. Thus, the Keplerian orbits of the planets were a *prediction* from Newton's theory, which was one of the things that made scientists accept it as almost certainly giving the cause of falling bodies. (It didn't, of course, as we saw.)

●**The point of the prediction is that *if* the theory states the true cause, *all* the predictions of both types *must actually be facts.***

We saw, remember, that the logic of "if-then" is that, given the *truth* of the "if," the "then" *must* be true, or the "if-then" connection itself is false.

●**Hence, if *any one* of the predictions from a theory turns out *not* to be a fact, the theory is falsified; it cannot be stating what really is the cause.**

And since there are an infinity of possible predictions from a theory, this offers a fertile field for investigation. Certainly **some** of these predictions must be observable; and if they are, you can go looking to see if they actually occur. If they don't, you can throw out the theory.

●**It is also the case that, the less likely some predicted fact is to be a fact on any other assumption by a theory, the more likely it is that if this fact occurs, the theory is expressing the real cause.**

DEFINITION: *Verification* is the process of observing to see whether predictions from the theory are actually facts or not. It is a kind of experiment performed on the predictions from the theory.

Let me illustrate these last few statements by Newton's gravitation theory and Einstein's relativity theory.

First, we note that Newton's gravitation theory predicted the orbits of the planets as elliptical. It also predicted that these orbits would behave in special ways (would "precess," to be technical) because of the gravitational attraction of the other planets as well as that of the sun. This also was observed. The theory also predicted *how much* this precession would be (though the mathematics of figuring it out, given all the planets, was formidable).

Here is where, as I mentioned, Newton's theory came a cropper. His prediction of Mercury's orbit was off by an infinitesimal amount; but the fact was that it predicted that Mercury would **have to be** in a certain place at a certain time, and *it wasn't there.* Clearly, the facts aren't at fault here, and so the theory had to be wrong.

Einstein then developed the theory that falling wasn't due to a *force,* but constant acceleration (i.e. constant increase in speed) is the natural way bodies move. But they move along the path of space-time; and in the presence of massive objects, this path is curved, so that the "natural fall" of something like Mercury is along the space-time path that (he predicted) would look like a certain shape. This shape was the orbit that was observed, which Newton's theory of a force missed.

But if space-time itself is curved, then light (which travels, of course, through space) would *also have to follow the curve of space-time,* and so would not travel in what we normally think of as a straight line. So this theory predicts "curved" trajectories for the light from a star, say, as it passes close by the (massive) sun on its way from the star to us. But since our eyes and seeing apparatus (like telescopes) are so constructed that we see things **as if** the light were traveling in a straight line (as the bent light from the oar dipped in water makes us see the **oar** as bent at the surface), then the way this "traveling in a curved path by the sun" would appear would be that the star would appear to be *shifted from its normal position* like the tip of the oar after you dip it in water.

But how to observe this? The sun is so bright that you can't see stars whose light passes near it. But during an eclipse, the sun is darkened enough so that telescopes can see stars which are very close to the edge of the sun: close enough so that the predicted shifting of apparent position would be observable.

And the stars *did* appear shifted out of the positions we knew they would appear to be in if the sun weren't there. Now this jumping around of the apparent positions of the stars is a fantastic event in itself; an effect that definitely needs an explanation. And light has no mass (no "rest mass," as they say nowadays), and so couldn't be attracted by any **force.** And the shifting was *exactly as much as Einstein's theory predicted.*

Put all this together, and it is very unlikely that Einstein's theory could have come up with an explanation that (a) was intended to explain the facts in question, (b) predicted an event not yet observed, which was extremely unlikely in itself, (c) predicted it exactly, (d) and the event was then observed to be exactly as predicted; and (e) was not the true explanation, but the prediction and the event's being as predicted was sheer coincidence.

You can see that (e) is *possible*, but, especially since the event is really very unlikely in itself, it is fantastic to assume that Einstein just happened by chance to predict it—especially when his theory explains **all** of the other data dealing with the heavenly motions, including those that Newton's couldn't.

And that is why predictions are so useful in science. If the theory predicts a "fact" that turns out not to be a fact, we can throw out the theory as maybe good speculation, but not really stating the cause.

But if it predicts an event which is unlikely on any other supposition, then it becomes very likely that the theory does state what really is the cause of the effect.

Now of course, Newton's gravitation theory should be a caution here. This prediction of what *does* occur *does not **prove** that the theory IS true, still less that it MUST be.* It simply makes it very likely that it is true. It still could be an explanation that is **very close** to the truth, but not really the truth.

●NOTE that the verification process *never proves* a theory to be true. It can prove a theory false, but no theory is ever really

totally verified.

It is always *possible*, then, for a scientific theory to be overthrown; though it may be extremely unlikely, depending on how many otherwise improbable events have been verified.

3.6. A prediction from this theory

So our theory, based on the simple assumption that scientists, confronted with apparently self-contradictory sets of facts, try to find the fact that makes sense out of this effect, has explained all the steps of the scientific method with their observed details, and while it was at it, made sense out of probability and induction. It sounds like a good theory. As far as I know, there is nothing that science does as such that is not predictable from this theory; if anyone finds anything, I would appreciate knowing it, so that the theory could be altered or scrapped in favor of something that fits all of the facts.

But there is a prediction that I would like to make from this theory. If science is based on apparently contradictory sets of facts, it would follow that there might be other contradictions appearing than are able to be handled by any of the sciences we know of.

For instance, there are problems connected with the *mere fact that* things change, irrespective of any specific **way** they change: How can something "turn into" something else, so that the "something else" is what *used to be* what it now isn't? Now, granting that this isn't just playing with words and is a real effect, it can't be handled by (a) physics, because physics doesn't deal with changes of one *kind of thing* into another kind of thing, but just changes of state; (b) chemistry, because this deals only with chemical changes, not physical or biological ones; (c) biology, because its changes are different from those of physics and chemistry—and so on. There is no science that deals with change *as such.*

Again, every science assumes that there is a world "out there" which we can observe, and say things about as it actually is. But if our perceptions are affected, not only by the world "out there" but by the conditions under which we perceive it, how can we say things about the world as it is in itself? But no science can handle this, because every science **starts** from certain observations of what is "out there." Even the psychological science of perception starts, not from the perception itself, but from observations of stimuli and reports of perceptions by subjects.

So there are important problems not handled—or even handleable—by any of what are called the "sciences." And some of these effects are vital to our lives. *Is* there, really, something that makes it make sense for a person to act honestly when it is greatly to his advantage to act dishonestly? *Are* we really free and in basic control of our lives, or is this inescapable idea that we are free an illusion, and we are the puppets of our environment and heredity? And so on.

These are general questions, but important ones. There *ought* to be a scientific way to handle them, so that we can come up with verifiable theories and falsify ones that don't work.

And so this theory predicts a scientific approach to *philosophy*. It should be possible to take these philosophical issues, state them as effects, develop hypotheses about what the cause is, test to see if these hypotheses fit the facts observed, and then *predict* other supposed "facts" from the theory reached, and *look to see* if these predictions are verified.

This would make philosophy—which has been hitherto regarded as pure speculation—into something scientific, where we could at least **reject** philosophical theories that predicted "facts" that simply don't occur.

And I have tried this method, and it works, I think. The rest of the book will be some of the results of what I have done dealing with general issues connected with bodies and how they change. I think this prediction is verified; whether there are other predictions of this theory of science which cannot be verified, only time will tell.

PART TWO

PHILOSOPHICAL STATICS

CHAPTER 4

ENERGY

4.1. The basic properties of all forms of energy

The object of this part of the book is to describe, from a philosophical perspective, the objects that physics and chemistry deal with—bodies—and to connect the philosophical description with the descriptions found in physics and chemistry. I think the process will yield some conclusions which might be useful in these sciences.

In this chapter, we want to take a philosophical look at what scientists are dealing with when they do things with what they call "energy." We are not really interested in examining *the scientific concept* of energy, but rather what is *referred to* by that concept—what the scientists are talking *about* when they talk about "energy." Of course, in order to show that what **we** will be referring to under the name "energy" is the same thing that scientists are referring to, we will have to examine the scientific concept; but this is secondary to our main purpose: what are we (and scientists too) talking about when we talk about energy?

First of all, scientists certainly think they are talking about something real when they are referring to energy; in fact, there is a kind of dogma in scientific circles that if whatever it is you are talking about isn't energy or some confiuration of various forms of energy, then you're just playing games with words and imagining things. If it's real at all, they say, it's really nothing but energy.

As it happens, this dogma is false, for reasons I don't want to go into at the moment; but it does give us a starting-point in that scientists are *referring* to something real rather than imaginary when they talk about energy.

The second thing that seems always true about energy is that it is (at least in principle) *measurable*. You may not be able to measure it directly, because you can't get an instrument into the system (as, for instance, the internal energy of an atom); but you can either measure how much energy there is **in**directly, or at least the energy *would* be able to be measured if there was a way to do it. It has, in other words, "what it takes" to be measured: there's always a certain *amount* or *degree* of it.

Beyond this, there seem to be all kinds of differences in energy; and there we get into the various *forms* of energy. All forms of energy are (a) real, and (b) measurable; but one form of energy may be totally different from another except in these two common characteristics. Also, (c) any energy is always *some* form of energy; there's no such thing as a certain amount of "just plain energy" of no form at all.

In fact, each case of energy is always a *given* form and a *given* amount—and the amount of one form of energy doesn't have the same numbers attached to it as the amount of a different form of energy. It sounds as if the ammount "attached" itself to the particular form of energy you are dealing with.

4.1.1. Being and activity

Let us, then, examine these characteristics from the more general perspective of philosophy. What

4.1.1. Being and activity

are you referring to or talking about when you are talking about something real?

This is actually a very complex subject, and really belongs in the branch of the science of philosophy called *epistemology*, which is the study of how we can know what is true. For those who want something more than the flying look you will find here, I refer you to my *Knowledge: Its Acquisition and Expression.*

For our purposes, we can oversimplify without actually falsifying, if we point out the following:

●We are aware that our experiences fall into two general categories: (1) experience-of and (2) spontaneous consciousness.

These would roughly correspond to perception and imagining, if it weren't for the fact that reasoning to the (unperceived) cause of something perceived belongs on the category "experience-of [something real]," while reasonings about what the unicorn knocking at your door wants belong in the category of "spontaneous consciousness."

Not to make a long story of this, when you "experience" a unicorn, you are aware that there's nothing beyond the experience itself; there's no such thing as a unicorn. You "made it up," as you would say; meaning, basically, that you took information *already stored in your mind* and put it together in such a way that you had this act of consciousness which would be **like** looking at a unicorn if there were such a thing to look at.

And this is why this is "spontaneous consciousness." You *don't need* anything more than your mind itself (with what is stored in it) to explain imagining; and that is why imaginary experiences are under your control. Imagine the unicorn. Imagine it to be blue. Imagine it to shrink to the size of a mouse.

●Note that that "picture" of the unicorn isn't a little unicorn "in your head." It *is* the act of imagining; you are not looking *at* anything at all when you imagine a unicorn; you are simply aware of the form of your own consciousness, because you know that there is nothing *except* your consciousness here.

This is important, though not terribly so for our purposes. The reason is that when you actually *look at* a horse, you aren't "really looking at" your little internal "picture" of a horse. What it is in your "looking" that corresponds to the "unicorn" is the *form under which you see the horse*. But what you are looking *at* is the horse itself, not your perception of it.

●It is impossible for experiences-of to need nothing more than our minds, because then we would not be able to distinguish the two different categories of experience.

That is, identical causes have identical effects; if *all* that explained our experiences-of were nothing but what explained our spontaneous experiences, then they would not be able to be distinguishable. But they are. There might be times when we confuse one with the other (as in hallucinations), but we couldn't have two different categories *at all* if both were caused by the same cause.

●Therefore, experiences-of are effects of some cause in addition to our minds and the information stored there.

DEFINITION: The *object* of consciousness is the causer whose effect is an experience-of.

The object is the causer, not the cause itself. What it is about the object by which it affects our minds is the cause.

●NOTE: spontaneous experiences have no objects.

So the experience "of" a unicorn is not really an experience "of" anything (except in that secondary sense, of itself); and you will notice that we say, "there is no unicorn."

> [NOTE: the preceding argument is not perfectly rigorous, but it will do for our purposes here. For a rigorous approach to what being and existence is, see my *Modes of the Finite*, Vol I.]

DEFINITION: *Being* is the object of consciousness.

But since being is "what exists," then

DEFINITION: Existence is the cause explaining the fact that we are conscious-of rather than imagining.

That is, when we are conscious **of** an object, we know that the object *exists.* It is *making* us conscious of it, because without it, our consciousness would be a contradiction (i.e. it would be in fact the same as spontaneous consciousness, but it is recognized as different).

And in fact, we recognize this; because we see that we have no control over the objects of consciousness. You can imagine the unicorn as blue; but you can only see this page as white with black letters on it; it *forces* your consciousness to be the particular perception that you are having.

Now then, since we recognize that in spontaneous consciousness, we are *actively creating* the particular act of consciousness (and doing it "by ourselves,"), we can take the next step, and say that we recognize consciousness-of by the fact that we are **passive**; that is, we are acting, but our action is really a *reacting* to something else.

And since the only thing you can react to is an act, then

●**Existence is *activity.*** This is being *as cause* of our reaction to it.

●**Being, therefore, is whatever is active.** Whatever has activity as an "attribute" of it is a being. This is the causer, the object.

●**Being known is the action of existence on some mind** (i.e. on something that can be conscious). This is the causality of existence *on* the mind. Note that "being known" is stated passively, as if knowing did something "to" existence; but actually, the causality is the other way round.

●**Knowing is the mind's being affected by existence.** Knowing is active on our part; but the particular activity is our *response* to the action of the object *on* us; hence, it is being-affected, not causality. **We** don't make the object known; it makes us know it. Of course, if we're not there, no knowing takes place; but knowing is not something we do **to** something, but the other way round.

Notice that reasoning about unicorns or other imaginary objects is not *knowing,* strictly speaking—because there is nothing to know about. It's just playing games with your mind and you consciousness.

●**Existence is not affected by the mere fact that we know it.** Remember, the cause is not affected by the fact that it is having an effect.

This is extremely important. What it means is that

●**Being is in itself independent of our knowledge of it.** We do not **alter** the existence of a being by knowing it; it alters **our** existence (and makes us knowers-of-it rather than ignorant).

"Well, yes," you might say; "but aren't there cases where you have to *do* something to an object in order to know it? For instance, you have to burn hydrogen to know its spectrum; you have to hit electrons with light to know where they are—which moves them from where they are—and so on. Doesn't this imply that at least in some cases, our knowing being alters it?"

That is true; but here our distinction earlier comes in. We sometimes must alter the *being* in order to know it; but once altered, the *activity* it produces (its existence) is independent of our knowledge of it. For instance, when you burn hydrogen, the *light* it gives off is the existence you know; and this light is independent of the way you see it. If you have jaundice and see it as green, it is still blue of a certain wave length. Or if you bounce a photon of an electron, the photon, rebounding is the **existence** which you see; and you don't act **on** the photon by seeing it.

So the caus**er** can be altered; but the causer is not the cause. The activity of being *which* acts on us is just what it is. Of course, the *way we see it* depends not only on the activity, but upon ourselves as affected objects; but this doesn't make the *act* depend on us.

The reason I am belaboring this point is that scientists have lately been bamboozled by certain conundrums in physics to assert that "knowing is doing something to what is known." But this mistakes the cause (existence) for the causer (being), and in fact makes (if you think it through) *all* objective knowledge impossible, and everything to be "really" just fancy forms of imagining. But this is absurd.

4.1.2. Form and limitation At the moment, I don't want to concentrate on the object itself (or on the being), which seems to be (and is) a complex of many activities, somehow unified.

●For this chapter, we will confine our attention to one single activity, and what can be said of it as energy.

In the next chapter we will consider the implications of systems of energy, and those tightly-knit systems called "things," "bodies," or sometimes "substances." They have their own special problems and effects.

What we know so far, then, about a single example of "energy" is *that it is* activity or existence. We would generally say that it is the existence or the activity *of* something (some being, or some body); but there seem to be cases of "free energy" (such as cosmic radiation) that are referred to as if they weren't properties of something else—and so it might be the case that there is such a thing as a single form of energy that "exists by itself," so to speak.

Note that, what is true of energy **as** energy will be true of it whether it is the energy "of" some body or whether it is something that exists in its own right. So we don't need to worry whether there actually exists "really free" energy or not; we are only interested in what can be said of **any** energy, "free" or "bound," simply because it is energy.

I mentioned that there are various *forms* of energy: heat, electricity, mass (yes, it is a form of energy), kinetic energy, and so on. Let us look at the implications of the fact that energy is always some form of energy.

Since energy is existence, or that by which we know being, we get at it through our knowledge (its effect on us). Hence, there is something about our knowledge of the existence we call "energy" that makes us say that there are different forms of energy. What is that?

●**We have different *kinds* of experience-of, allowing us to classify many instances under one category,** such as "seeings," "hearings," etc.

That is, there are many examples of hearing, but they are all the same in some respect (as hearing), though a trumpet sounds different from a flute. But trumpet-sounds and flute-sounds as heard belong in a different class altogether from green color and blue color.

Now can this classification into different types or kinds of experience-of simply be due to ourselves and *not* to a difference in the objects we perceive? After all, any experience-of is a reaction of our mind **to** some activity; and so the experience is the effect of *both* the mind **and** the object. So it is at least in principle possible that the activity might be the same and the difference due simply to the fact that **we** are different as "receivers."

It might seem that this is true, because we hear sounds with our ears, and see colors with our eyes; we have two different "receiving instruments," and this might explain the difference in the experiences.

But it cannot *totally* explain the difference, or we would be able to see the sound of a trumpet if we paid attention to it (if the sound in itself was just the same as a color), or hear the color blue. But we can't do this. Therefore, there must be *something* about *any* sound that makes it capable of being heard by ears and not seen, and something that *all* colors have in common that makes them able to be seen but not heard.

4.1.2. Form and limitation

DEFINITION: The *form of activity [form of existence]* is whatever it is about the activity [existence] that allows it to be known as a *kind* of activity or existence.

It is the cause *in the activity* by which it is "classifiable" by kind.

Now what can be said about this?

●The form of activity is *not an activity*.

If it were an activity, it would be an activity *different* from the one we were considering, and would have to be perceived as a different existence. Hence, it is not itself an activity, but something **about** an activity.

This is confirmed by the fact that if the form of activity were an activity, then it would be something *added* to the activity, and then the activity in question would be *greater* than "activity-itself" (because it would be just "activity" *plus* something). But this is absurd. We experience a given form of activity as *less than* what it is to be active.

That is, color is *only one form or kind* of activity; it is *not all there is* to "being active," let alone "more than what it is to being active." So the form can't itself be an existence or an activity, because it somehow "makes" the existence less than what it otherwise would be (i.e. what it would be if it were not some form of existence).

●The form of activity is not *simply nothing*.

We have to be careful here. If the form isn't an activity, then it is not existence, and can't be known. And it can't be, really; all that can be known is the activity that *has* this form. That is, when you know color, you don't know the form "color," you know the *act* which is green. The *form* can't act on you without being an act.

But the form can't **act** on the activity, really, either, "making" it only color. If it could, then it would be an additional act, and the color would be *greater* than activity, when in fact it is less.

But then if the form can't act on us and can't act on the existence which acts on us, then it isn't anything at all, really.

But this would make the form itself imaginary or subjective; and that isn't true either, because we said that there has to be something *about* the activity that allows for its being known as a kind of activity.

●The form is a *limitation* of activity; it is *the fact that* the activity *is nothing beyond* the kind of activity in question.

So the solution is not that the form is something that somehow "does" something to the activity, limiting it, but is simply a *fact about* the activity itself: the fact that it is *only this kind* of activity.

Color, then, doesn't *have* something (a kind of "real nothing") that makes it just color; it is simply activity that is *no more than* just color-activity; it is the *activity itself* that is the color, not the activity + something.

And this is why it is the "form of activity." There is and could be no such thing as a form that wasn't a form of activity, because the form is a *description of the activity*, not something in its own right. It is to activity something like what temperature is to heat. The temperature of the heat isn't something in addition to or "attached to" the heat; it is simply the description that the heat is no more than this intensity of heat. So the "heatness" of the heat (its form) is simply a discription of the fact that the heat is nothing other than heat-activity. You can't have a temperature that isn't a temperature-**of** heat, and you can't have a "heat" that isn't a heat-*of* activity.

●**Any form of activity, as limited, *falls short* of what it is to be activity, and so "leaves out" some of itself as activity.**

That is, the form of activity is nothing but activity; and as such it is the same as any other activity. What makes it different from any other is **not** something it *has*, but the fact that it *lacks* something of what it means to be active: something different from what the other form of activity lacks.

But the only intelligibility or reality it has is that of activity itself; and so it lacks something of what makes it intelligible as itself.

If this sounds confusing, it is because I am describing an effect. Something which is limited leaves something of what it is out of what it is—and this doesn't make sense.

We are not going to pursue this particular effect, except to note that it **is** an effect, and (since **all** forms of activity are limited and thus identical as effects in this respect), to point out the fact that, whatever the cause of this effect, it can't be a form of activity or any limited activity (because then it would be the cause of itself, which is absurd—since it would be a limited activity which is and is not an effect). [Again, this is explored in detail in *Modes of the Finite.*]

●**The fact that activities are limited means that there must be an absolutely unlimited activity as their cause. This unlimited activity is called *God.***

For those interested in investigating this line of reasoning (which can become very complicated, in order to make it rigorous), I refer you to my *The Finite and the Infinite.*

4.1.2. Form and limitation

For those who want a model, consider the surface of, say, a wooden ball. The wood in this analogy would correspond to the activity, and the surface to the form of activity. What is the surface? It is what “makes” the wood a ball and not a cube; but it is *nothing but the wood*. That is, if you carve off a quarter inch from the wood, you have *put* a new surface onto the ball that wasn’t there before (there was no “surface” hidden under the surface), and so the surface is nothing *in addition to* the wood; it is simply where the wood stops “wooding.” But the wood *does* stop. The surface is the *fact that the wood extends no farther.*

So what is the problem? If the surface is identical with the wood, really, then wherever there is wood, there would really be surface. But this is not true; there is no surface an inch below the surface. So the surface is *not* the wood.

So the surface is either a real nothing or a real lack of woodness in the wood—either of which doesn’t make sense by itself. The surface is simply a limitation; but “simply” a limitation is not so simple; the word expresses something that gets more mysterious the more you try to figure it out.

4.1.3. Quantity Let us, however, be content with the fact that any form of energy, as a form of activity, is a limited case of activity, and the fact that the forms are different simply means that the activities “lack” activity differently; so heat lacks whatever sound has that makes it active, and sound lacks whatever light has that makes it active, and so on.

But to get to what energy involves, we have to take another step. All energy is not only a form of energy, but measurable. What does this mean?

It is connected with the fact that there are *many different* sounds and many different colors and many different cases of heat. Let us consider heat, because it is clearest to describe.

Heat of fifty degrees does not differ from heat of seventy degrees *as heat*. Both of them are "equally" heat, in the sense that you can't describe either of them as anything else but heat. Then how do they differ? Obviously, the heat of fifty degrees is *not as much heat* as the heat of seventy degrees (or perhaps is not as intense, if you prefer).

DEFINITION: *Quantity* is the limitation of a *form* of activity to being *only a certain amount* of the form of activity.

This is another limitation, and so as such is nothing in itself; it is the fact that heat of fifty degrees **falls short** as heat of heat of sixty or seventy degrees. Clearly, the temperature (the quantity of the heat) is not, as I mentioned earlier something *added* to the heat.

To give a model, the quantity is like the edge of a surface that has edges—such as a cube. Unlike a ball, whose surface is, from a certain point of view, continuous, if you go along the surface of a cube, you come to an edge where, to remain on the surface, you have to change direction. Note that at the edge, there is nothing there but the wood, really. But the edge is not just the wood; it is where the wood stops; but it is not just the stopping of the wood, either; it is the stopping of the **surface** (the stopping) of the wood. It is a limitation-of-a-limitation of the wood; a kind of nothingness of a nothingness of something.

It is, of course, limitation at this level that allows us to *measure* the form of activity. Clearly, if the form of activity were unlimited as a form, you couldn't measure it, because we compare forms with each other as different *kinds* of activities, not as different degrees. That is, it doesn't make sense to ask how much more activity heat is than sound—supposing that you aren't talking of a certain degree of heat and a certain degree of sound. Heat as such is just different from sound, but not less than it or more than it. In order to measure, you have to have something in common between the two things measured, so that you can set up your scale of numbers; and this "common element" is the form of activity in question. Heats can be compared with heat and sounds with sounds.

It is not this simple, of course. Since forms of activity can be transformed into each other, indirectly we can compare between acts. The formula for the mechanical equivalent of heat, for instance, says that when mechanical energy is transformed into heat, a certain quantity of the one becomes a definite quantity of the other. Or Einstein's famous equation, $E = mc^2$ says that when mass (a form of energy) is converted into light (another form), then the number 1 of 1 gram of mass becomes the quantity 3,000,000,000 of units of light-energy. But unless you can convert one form of energy into another, there is no way to measure one "against" the other. Note that in the transformation process, it is assumed that somehow the quantity "remains constant" even though the forms have been altered. If the quantity is a limitation (a nothingness) of the form, which in turn is just a limitation (a nothingness) of the activity, this "remaining constant" is really wierd; and we will have to treat it later.

In any case, for our present purposes, it seems reasonable to say that

●**Quantity (the fact that forms are limited) is what allows for the possibility of measuring things.** It is the "aspect" of an activity which is its "measurability."

4.2. Energy Since we have now described what all the things that science talks about under the name of "energy" have in common, we are in a position to give a philosophical definition of energy.

DEFINITION: Energy is any activity that is limited both in form and in quantity.

Note several things here.

●**First,** energy is *not* the quantity itself; it is the *activity.* Energy has forms; quantity doesn't, because it's the quantity *of* a definite form of activity. Energy is measurable; quantity is the internal cause in an act of its measurability. In one sense, the quantity is measured; but in another sense, the energy is measured. That is, when you measure some energy, you are measuring a caus**er** (the energy) which has characteristics (such as heat) other than the quantity (the cause) you are measuring. So in this respect, the energy can't be the quantity either.

●**Secondly,** activity is called "energy" *only* if it is quantified (i.e. limited in form and quantity). In order to be limited quantitatively, of course, the energy has to be limited in form, because the quantity is a limitation of the form of the activity, not the direct limitation of the activity itself.

●Thirdly, *energy is an analogous term.* All forms of energy are *somehow* the same (in that they are activity, and that they are quantified); but they are also somehow different. But, though we can give the "differences" (the forms) separate *names*, we don't know exactly what they are. This is especially true since the forms are simply the fact that the energy lacks something of itself, and not something the energy really has.

Hence, each form of energy is the same as all others in some real (but not observable) way and different from all others in some real (but not observable) way. But this, as we said two chapters ago, is what you mean by "analogous" rather than "similar."

●Fourthly, *not all activities are energy.* We saw that, since any form of activity needs as its cause an infinite activity, then clearly there is at least one activity that is not limited at all (i.e. is simply the act that is the same as "what it is to be active," and isn't any kind of activity or any degree or amount of activity). But this act can't be called "energy," because it has no quantity.

So the scientific dogma that "if it exists, it is energy" is proved false right at the start. *If everything were energy, nothing would exist,* because energy in itself is a contradiction (as limited) and there would be nothing that could be its cause.

It might well be that there are *forms* of activity that are not quantified also—and it turns out that consciousness is one of these. We will not try to establish this here; but there is certainly nothing in principle impossible in something's being a form of activity but not internally limited and so being an unmeasurable form of activity. If you want the evidence for consciousness as not quantified, see my *Living Bodies.*

DEFINITION: Activity that is *not* limited quantitatively is called *spiritual* activity.

So energy is opposed to spiritual activity. Usually, "spirit" is opposed to "matter"; and we will see why energy is "material" later. For the present, let us simply be aware of the distinction, so that we can realize where we stand. It does explain, as you can see, why scientists who subscribe to the dogma that all that exists is energy are "materialists."

Note, by the way, that an activity or form of activity that is not limited is not one that "has an infinite quantity." An "infinite quantity" is a contradiction in terms, because as a quantity it is **a limit**; and so an infinite quantity would be an "unlimited limit."

This is why mathematicians say that a certain value "becomes infinite" rather than "approaches infinity." The number "infinity" (4) does not really exist as a number; it is a symbol of something's becoming arbitrarily large.

So when we speak of a spiritual act as "infinite" with respect to quantity, we do not mean that it has an enormous quantity; we simply mean that *it cannot be described in terms of quantity*, the way "colorless" means that glass, say, cannot be described in terms of color. "How much is it?" is a meaningless question of a spiritual act, just as "What color is it?" is a meaningless question of what is colorless.

●**Fifthly,** if an act is to be called "energy", *it will always in principle be able to have a definite number placed on it.* The quantity implies a *definite* limitation, which makes it in principle measurable; and measurement will result in a definite number, indicating that the act is *no more* than this.

The reason I say that it is *in principle* able to have a number placed on it is that it might not *in practice* be possible to do it for either of two reasons: (a) no instrument which can react to this energy is known (as would be the case if whatever causes ESP [extrasensory perception, if there is such a thing] is a form of energy); or (b) it might not be possible to get an instrument in a position to measure the energy without disrupting the object in such a way that measurement is impossible (as when you try to measure the "binding energy" of a body; to get an instrument in there would mean it would have to become part of the body, which would wreck the body). But in either of these cases, **if** an instrument could be found or if it could be introduced, *then* it would register a definite number.

In other words, quantity is the *cause* of the definite number you get when you measure, but not the *causality*, which needs the effect in order to be what it is.

4.2.1. Energy in physics

Now what is the relation between "energy" as we

4.2.1. Energy in physics

have defined it and "energy" as science uses the term. Let us take physics as the science to look at. In first-year physics, you learn that "energy is the capacity for doing work"; but as you get along in the subject, you find that this is an oversimplification, and there are all kinds of mathematical definitions of energy.

This would not be at all surprising, if, as we said, energy is an analogous term, and means something different but (in some unknown way) similar each time you use it. So the different mathematical definitions of energy confirm that our philosophical description of it is on the right track. That is, you could have predicted from our philosophical description that there wouldn't be just one cut-and-dried definition in physics—and there isn't, really. Energy in physics is got at indirectly, through work.

This again sounds reasonable, based on our definition. If energy is activity, then (as we saw) it is *known* as the *cause* of some effect. In our case, we saw it as the cause of our consciousness of individual objects of a given type (they being the causer). Apparently, physics considers energy (the "capacity") as the cause of the effect called "work."

4.2.1.1. Work Well, what **is** "work" as physics uses the term? It is defined as "force exerted through a distance," and mathematically is the "scalar product" of force and distance. (Don't worry about this; it simply means a kind of multiplication which results in a number without a direction associated with it.)

It sounds as if we are getting wheels within wheels; we need to define "force" before we can define "work." But let us look at the matter qualitatively, using moving a block across a table as our example.

The block tends to remain at rest and to resist a change in its state. The fact that it got to be moved a foot across the table means that something had to be *done* to it to get it to move. Not only *something* had to be done, but if it is to be moved two feet, you would have to do *more* to get it moved the extra foot.

It can now be seen what is going on. You can *directly measure* the length moved, and you can measure the *degree of resistance* to the movement, and so on. So you can measure the *amount of the effect*. It is then argued that the *cause* will then have *the amount necessary* to produce this effect.

DEFINITION: *Work* is energy *as* the effect of some other energy.

It turns out that the work itself is, in a sense, energy; but it is *used* to find the energy of whatever did the work. The work is something that is for some reason measurable in itself, and it allows you to find the quantity of the energy that did the work.

And here is the difference between the approach of physics and that of philosophy. Philosophy notes *the fact that* any form of energy *has* (some) quantity, but it doesn't care what the quantity happens to be in a given case. Physics *wants to know what the quantity is*, and hence must devise ways of finding it. When the energy is the *cause* of something, then its quantity will not be *directly* observable (because you observe the effect and argue to the cause); and hence you have to argue to it based on the quantity of its effect.

And that is why energy is related to work.

Having said this, we then find that there are all kinds of analogous descriptions of work. The heating of the filament in your light bulb (i.e. going from, seventy degrees to several thousand degrees) is a kind of work, though no "motion through a distance" has occurred. But obviously, a *measurable change* has; and so the total can be arrived at. And this allows you to measure the electrical energy which caused it.

4.2.1.1. Work

DEFINITION 2: *Work* is any complete measurable change.

That is, it has to be "complete" in the sense that you have to be able to give it (even if arbitrarily) a beginning-point and an ending-point. Otherwise, you can't put a definite number on it. Thus, you could consider how much energy is expended making the hand of your watch make a full revolution. True, the watch's motion didn't start at the time you started measuring it, but *for your purposes* it did; and it ended when the hand came back to the same position. Then, you can measure the tendency it has to stay still, and combine this with the total "length" of the process where it didn't stay still, and come up with a definite number; this will be the work **done on** it; and it will correspond with the amount of the energy needed to effect this change.

So the two definitions complement each other. Any complete change is a case of "energy-as-effect"; and so any complete change will reveal the *amount* of the energy which is its cause.

And that is why, in physics, energy is "the capacity for doing work": it is the cause whose effect is some measurable change.

4.2.1.2. Fprce So far, then, we have the effect (work) and the cause (energy). Are there other parts of the cause-effect relation hidden in the concepts of physics?

There are, as it turns out. If we look at Newton's third law of motion (whose integral results in work on one side of the equation and energy on the other), we will see something interesting:

$$F = ma$$

This is the equation which "defines" force. It says, mathematically, that the force is equal to the product of the mass (the tendency to resist a change of motion) and the acceleration (the tendency to change one's motion).

So on the right-hand side of the equation, you have two tendencies: tendencies *in the object which is about to move*. When the movement actually has occurred, of course, what you get is the *work* done on it. But here, all you have is the *tendency to have work done.*

In other words, the right-hand side of the equation expresses the *being-affected* of the object by the energy which is causing it to move. It is expressed, mathematically, as an *instantaneous something*, which means it is a tendency rather than an actual movement. And what *that* means is that it is the affected object *insofar as it is related to the cause*—or it is the "being-affected," as I said.

From this it follows that

DEFINITION: *Force* is the *causality* energy exerts on some affected object.

That is, the left-hand side of the equation is the relation looked at the other way; it is what the causer (the object containing the energy) is tending to do to the resisting object. The right-hand side is what is being done to the affected object by the causer; the left-hand side is what the causer is doing to it. It is the same relation, and so it is not surprising that there is an equation here.

DEFINITION 2: *Force* is *causality as quantified.*

Once again, what physics is interested in is *what the quantity in a given case actually is.* And once again, the quantity of some cause cannot be directly got at, nor can the quantity of the causality it exerts. But it can be got at through the fact that it is tending to cause a change—and through the *degree of resistance* to this change on the part of the affected object.

4.2.1.2. Force

If we set up the force equation this way:

$$F = m\,(vdv/dx)$$

we can see something interesting. That (vdv/dx) is a mathematical "derivative," which is the instantaneous *tendency* of the velocity (the motion) to change with respect to the distance over which it changes. Physicists state the equation as the tendency of the velocity to change *with time,* which masks what is really going on; a little mathematical manipulation will convince them that my equation is the mathematical equivalent of theirs.

If you "separate the variables", then you get this equation:

$$F\,dx = mv\,dv$$

And if you now integrate, you get

$$F \Delta x = mv^2/2$$

where the left-hand side is the work, and the right-hand side is the kinetic energy.

For those who hate mathematics, what this all boils down to is that the force equation is simply the work-energy equation reduced down to an instantaneous tendency; and when you manipulate it according to the rules of the calculus, you get the work done and the energy that did it. So the work is the effect, the energy the cause, the force the causality and the mass-acceleration the being-affected.

●**Note that it would have been predictable from our theory of science that, if science is the search for causes from their effects, the key concepts of physics would be in terms of the cause-effect relation.** And this seems indeed to be the case.

4.2.1.2. Force

4.3. Qualitative mathematics

One of the peculiar things about physics (and chemistry too) is that the mathematics doesn't deal just with numbers, but with what are called "units." That is, the two equations:

$$F = ma$$

and

$$E = IR$$

are mathematically identical, since which letters you use to represent what you are talking about make no difference, and neither do upper or lower case. But *in physics*, they are very different, though they are *analogous* to each other. The first is Newton's third law and says, as we saw, that the force is equal to the product of the mass and the acceleration. The second is Ohm's law, which says that the voltage-drop is equal to the product of the current (I) and the resistance (R). Resistance is sort of analogous to mass, and current something like acceleration; but even mathematically, to convert the Ohm's law equation into a strict force-equation, you have to take the reciprocal of one of the terms. But let us let that ride.

The point of interest here can be illustrated by looking at an example of Newton's law; say, this one:

$$1 \text{ dyne} = 1 \text{ gm} \times 1 \text{ cm/sec}^2$$

What are those funny words? The "units." Physics teachers get very angry with you if you leave off the units. Why?

Well, if you want to convert it into the form I had before, with velocities and distances, it will look like this:

$$1 \text{ dyne} = 1 \text{ gm} \times 1 \text{ cm/sec} \times 1 \text{ cm/sec} \times / 1 \text{ cm}$$

dv has the same "units" as v (cm/sec), and dx the same units as x (cm). To show what is going on, notice that there are on the top of the right side two cm's multiplied together; and on the bottom two sec's and a cm multiplied together. The two sec's become sec^2 when multiplied, and the cm divides the cm^2 on top and leaves only one cm. So the result is the equation above.

But what did I do when I multiplied sec's by sec's and divided cm's by cm's? *I was doing mathematics with the forms*, not the quantities. These "units" aren't *numbers;* they represent the *forms* of the energies in question.

What does this mean?

•Quantities of one form of energy are only *analogous* to quantities of another. Hence, one must keep track of what *form* the quantity is the quantity of.

As can be seen from the equation above, 2 dynes could be equal to 2 grams x 1 cm/sec^2 pf acceleration, or 1 gram x 2 cm^2 of acceleration; but what 2 dynes does *not* equal is 2 of *everything* on the right sice. The units of force *vary differently* from the units of acceleration or the units of mass, so that 2 of one is not the equivalent of 2 of the other.

What the physical equation expresses is *the relation among the quantities of the various forms of energy involved*. If, for instance, we take the work-kinetic energy equation and "put in the units, we find this:

$$F \cdot x = m \cdot v^2/2$$

or:

$$1 \text{ dyne x cm} = 1 \text{ gm x cm}^2 / 2 \text{ sec}^2$$

The "2" in the equations is a "pure number," not expressing the quantity of some form of energy.

So "work" is expressed in dyne-cm, while energy is expressed in gm-cm^2/sec^2. The quantities of work are analogous to the quantities of energy, and the relation is what the equation expresses.

The reason you can do a kind of "mathematics" of the forms themselves (e.g. dividing sec by sec without numbers) is that *the forms are limitation* and as such are analogous to quantities.

But since the forms aren't *really* quantities, then the mathematical manipulation of them is pretty primitive and not the same as ordinary mathematics; they are similar *somehow* (i.e. as limitations) to quantities, but the precise *way* they are similar is not directly observable; hence, the way they are treated is different from the way the numbers "attached" to them (the actual quantities) can be
treated.

In any case, this is an explanation of why, when physics or chemistry uses mathematics, it doesn't do "pure" mathematics (which deals with quantities as such or limitations as such and ignores what is being limited by them), but keeps track of the forms as it manipulates the quantities. If you don't "put down the units" as the science teachers say, then you're doing mathematics, not physics or chemistry or biology, or even economics or sociology.

4.4 Fields Energy, once you have got round the strange implications of being limited, seems perfectly straightforward: you have an act which has a form and a quantity. But the real world is rarely as neat as our little categories would like it to be, and I want now to consider a peculiar type of energy: the field.

DEFINITION: a *field* is a form of energy which has an infinity of quantities all at once.

4.4. Fields

In a sense, of course, a field has only one quantity of energy (the total energy of the field), and in this respect one field will differ from another of the same type. Thus, for example, the sun's gravitations field is much stronger than the earth's, which is much stronger than the moon's.

But what makes a field a field rather than some other type of energy is that,when it acts on something, the *force* it exerts on the same type of object *differs*, depending, as we would ordinarily put it, on the *location* of the object in the field: how “far away” it is from the object which has the field. And if the force differs, so does the work it does, in the same way; and if the work does, then the energy in the field has different quantities, depending on “where you are” in the field.

Why do I put "far away" and "where you are" in quotation marks? Because these terms are our way of describing the field *in terms of its effects*, really; and, as I am going to try to show, location, distance, and position are not “somethings” that exist in their own right (and which you can then use for describing the field). The truth is the other way round.

That is, what *exists* is the field, with its set of quantities. *This* is the reality, and the *only* reality involved in spatial relations. The “locations,” “distances,”“positions,” and (the sum of all of these) “space” are *descriptions* of this same set of quantities in terms of its *work* or its*force* (i.e. in terms of its effects on other objects).

To put this another way, there is no “reality” called “space” which is independent of energy and “in which” you can measure distances and so on. We know this both from this philosophical theory and from physics.

From this theory: How could there be a measurable reality which was not energy? Energy is the *definition* of measurable existence. How could a “measurable non-energy” be known? It would have to *act on* us somehow for us to know it, in which case, it wouldn't be just "sitting there"; it would be doing something-or it would be energy.

From physics: Einstein's theories of relativity showed that, physically speaking, an "absolutes position in space" is meaningless. You can only talk of position or location (or movement—change of positions) in *reference to some object*—that is, at a distance (or change of distance) *from* some object or set of objects. And, as Einstein showed, the very position is altered by the makeup (the mass) of the object from which you are defining the position, so that it "warps" the space-time around it. He is talking about the gravitational *field* of the object as what it is that *defines* the positions and movements *in that field*, which is just what our philosophical theory demands if you are going to talk about space as a reality.

So we will take it that what is "primitive" isn't space, but the field, with its infinity of quantities; and space, distance, and position are *derived* from the field.

Now then, the field itself is an abstraction, got at by comparing various objects that have the same type of field and noting how they affect various other objects-and then paying attention to what all the fields of this type have in common.

That is, if one object has a field with twice as much total energy as another, then it will act twice as strongly on a given object as the other one, at "corresponding points" in the field. What this amounts to is that its set of numbers will be just double the other field's set of numbers all along the whole string; and so you can ignore this variation and get at the variation in intensity of the field *as such*

It is a little hard to talk about this without using the way we ordinarily look at things to illustrate it. Let me show what I mean, and then make the correction. Let us say we have two objects with electrical fields around them, with A's field being twice as strong as B's.

If we take a little object that can be affected by an electrical field, and put it a foot away from A, we find that the force exerted on it, say, is 200 dynes. If we put it a foot away from B, the force exerted is 100 dynes. If we put it two feet from A, the force exerted drops to 50 dynes; if we put it two feet from B, the force drops to 25 dynes. If we put it three feet from A, the force is now 22.2 dynes; at the same distance from B, the force is 12.5 dynes. At four feet, A's force is 12.5 dynes, and B's is 6.25 dynes. Etc.

Each time, the force exerted by A is twice that exerted by B; but in each field moving the object twice as far results in a reduction to 1/4 as strong; 3 times as far, 1/9 as strong; 4 times as far, 1/16 as strong; n times as far, $1/n^2$ as strong.

It is this latter set of numbers that is the field **as such,** because it will be true of *any* field, no matter what its total energy.

But you will notice that we arrived at the set of numbers by measuring "distance away" with a ruler, as if there were some kind of "space" in which we could figure out the distance *first* and then get the force based on it.

This is what I contend is backwards. What is real is the set of numbers that varies in a definite way; the "ruler-distance" is what varies in a peculiar fashion with respect to **it,** not really the other way round.

4.4.1. Potential I am aware that what I am saying is apt to be a bit mind-boggling; but perhaps it will become clearer as we proceed. If you keep in mind that what is real is energy, not something that just "sits there" (space-as-we-imagine-it); and if you are aware that the approach I am taking can make sense out of some things that physicists simply can't make head or tail out of now (because they take the common-sense notion of distance and so forth), then it might be easier to plow through all this.

To take something fairly easy first:

DEFINITION: The potential of a field is *one* of its *actual* quantities.

That is, here we are talking about the concrete field of some given object (so we are not ignoring the variation due to the different strengths of the sources). In physics, the "potential" of this field is defined as "the work done on a unit object if it is taken from infinity to the point in question."

"Work" should give us the clue that we are trying to define "energy" here; and so the "potential" is the "energy in the field at this point." It is got at through the fiction of "moving" this "unit object" (something that can be affected by the field in question) from infinitely far away to this point—an act, needless to say, which is never actually done.

What the "potential" abstracts from is the differences to which this energy would affect *different affected objects*. Thus, the potential of the sun's field at the point where the earth is now is the same whether the earth is in it or Jupiter or Mars or some other object. But if you were to replace the sun with some star twice as massive, the potential would be double at this point. So the potential takes into account the variations of *the energy as cause* and *the field variation*, but **not** the variation in actual work due to the varying nature of the affected objects.

So it is the energy "in the field at that point," which, from our peculiar way of looking at it, simply means one of the actual quantities that this field has.

4.4.2. Distance

The next easiest concept needs to rely on the abstraction from the different *actual* energies due to the different total strengths of the fields and consider simply the *field variation* of quantities (the "inverse-square variation") itself.

So we take an imaginary object with a "field of unit

4.4.2. Distance

strength" and have it act on an imaginary object of "unit ability to be affected." What do we get?

DEFINITION: *abstract real distance* is the *causality* of a "unit" field on a "unit object." Or, alternatively, *d*istance is the *force* of a field *as such.*

Distance is obviously a relation ("from" something "to" something else); and if it is to be something that is not imaginary, it has to be a relation established by activity; and if it is to be real *and measurable,* it has to be a relation established by *energy*, or in other words, a *force.*

But we have the field and for every quantity of "distance-as-we-know-it" there is one and only one quantity of the force of the field as such. Hence, the reality which causes our *reaction to* distance (i.e. "distance as it appears to us") must be this force the field exerts on things.

Now this is *abstract* real distance, because it ignores the *actual effect* the actual source (with its non-unit strength) is exerting on the actual object (with its non-unit ability to be affected). Obviously, this **real** causality will be different for different objects in the same **abstract** position in a field. But it can be useful for physicists to consider distance as it actually exists, and so let us define it:

DEFINITION: *concrete real distance* is the actual force some object's field is exerting on some real object.

Thus, the concrete real distance from the sun to the earth is how much the sun's gravitational field is affecting the earth at this instant.

●Note that *each field* of a given object will have its own *concrete* real distance to a given other object; and they will not necessarily have the same quantity. But the *abstract* real distance will be the same for all fields of the same type.

That is, the sun's magnetic field acts on the earth too; and so its force establishes a *magnetic* distance of the earth from the sun, while the distance I referred to above was the *gravitational* distance from the sun to the earth; the two would not necessarily be the same. If you take the abstract distance, however, then (since both are "inverse-square" fields), then they would be the same.

4.4.2.1. Near and far At this point, some of the peculiarities of this approach emerge. The field's force *diminishes* in the direction of "far" and *increases* in the direction of "near" (and, of course, in accordance with the *square* of the "distance as it appears to us"—what we measure with rulers). Hence, the numbers of distance regarded as we have above will look funny.

●Real distance is *greater* the *nearer* one comes to the source of the field; it is *less* the *farther* one is away from it.

So, for instance, when the real distance increases four times, the object is **perceived as** twice as close; if the real distance **de**creases to 1/4 as much, the object is perceived as having moved twice as far away.

The point here is that the "twice as close" and "twice as far" are not *realities as such,* because there is no real *activity* or *force* corresponding to them; what they correspond to in the world of **activity** is the forces and their variation.

Wierd? No stranger than Einstein's "warping of space-time."

4.4.3. Position If you got through that section, this one will be easy. Obviously, distance and position are correlative terms; we know the position of something by the distance it is from something else. And causality and being-affected are the two correlative ways of looking at the cause-effect relation; and so it follows that

DEFINITION: The *abstract real position* of an object is its *being-affected* by another's field as such. That is, it is **The degree to which it would be being-affected if it were a unit object in a unit field.**

Again, we are making an abstraction from the actual (total) strength of the field and the actual ability of the object to be affected, and simply talking about the relation based on the field as a field.

But once again, it can be useful to know the what the relation among the concrete objects is, and so we have the other definition of position:

DEFINITION: The *concrete real position* of one object with respect to another is its *actual being-affected* by the field of the other.

The concrete real distance and the concrete real position are what actually exist; the abstractions are just that: abstractions; and "distance as we perceive it" and "position as we perceive it" are not just abstractions, they are abstractions based on certain *effects* of these field-relations.

4.4.3.1. Non-reciprocal positions Now we get into a problem that this odd notion of position can solve. If position as a reality is the being-affected by some field, it is *not logically necessary that if A is in position with respect to B, B must be in position with respect to A.*

What do I mean? In general, if one object is acting on another, it is not **necessary** for the affected object to be acting on the causer. I mentioned that if you hear the radio announcer tell you bad news, you are affected by *him and his words*, but *he* is in no way affected by the fact that you had the radio on and heard what he said.

And this is also true in the physical world. "For every action there is an equal and opposite reaction" is an oversimplification, at the very least. If you just take the radio you are listening to itself, then the transmitter is the causer of the events happening in it (the various electrical impulses going through the transistors), and the varying signal of photons coming out through the transmitter is the cause of this effect in the radio. But *what happens in the radio* makes no difference either to the transmitted signal or to the transmitter—neither the cause nor the causer is affected in any way by the radio's being on and being affected by the signal.

So in *some* cases, there is an equal and opposite reaction for an action, but in some others, the causality *goes only one way.*

But can this be true of position?

It seems it can. Photons (units of light) have no gravitational *field,* (i.e. have no "rest mass"—this is what that means), and so cannot *act on* other objects in a gravitational way; but, as Einstein showed, they can *be affected* by gravitational fields, to a definite degree.

Hence, *photons can be in position, but other things cannot be in a position with respect to them.*

This sounds very peculiar. All it means is that they can be acted *on* gravitationally, for instance; but they can't *do anything gravitational* to anything else, because they have no gravitational field to do it with. They are like radios, which can receive signals but not transmit them. If we have no problem in the one case, why should we have one in the other?

And it turns out that there are certain interference experiments in physics which make sense only if the photons are in position with respect to their surroundings but their surroundings are not in position with respect to the photons.

It isn't that simple, of course. Photons *can* act on certain things (like photocells); and, though this isn't a *field*-action, it still is an act of causality; and so you can say that, in a sense, it establishes "where" the photocell is with respect to the photon.

Now then, in the experiments I am talking about [for those interested, they are the Aharonov-Bohm experiment with photons, and an analogous experiment—with interesting sidelights—dealing with electrons by Mullinstedt], photons [or with Mullinstedt, electrons] were made to travel down a path, and then by mirrors [a positive charge], split into two separate paths, and then again by mirrors be brought together into a single beam again. The light was cut down so that it could be known that there was only one photon in the apparatus at once—which would mean that each photon would have to (a) split and go down both paths, or (b) go down only one.

The reconstituted beam at the end was focused on a target, which (not to bore you with the details) made it possible (by what is called "interference") to discover whether the beam was split in two (implying that each photon went down both paths) or not. If each photon went down only one path, even though the right-hand path was used half the time and the left-hand path the other half, the interference pattern would not occur.

Detectors were also placed on the paths during the "split," so that, when turned on, you could discover whether the photon was really in that path or in the other one; or whether half of it was in each path.

What happened turned the world of physics inside out.

A) If the photon-detectors on the paths were *not* turned on, the interference-pattern indicated that each photon split in two and went down both paths. B) If the detectors *were* turned on, *only one* was activated for each photon (randomly, either the left one or the right one), indicating that the *whole* photon went down *only one* path; and this ruined the interference pattern at the target—which was consistent with the photon's going down only one path.

So the result seemed to be that *if you didn't detect what the photon was doing,* it split in two and was in two places at the same time (as a wave can be as it spreads out from its source); but *if you detected it*, it was in only one of the two places.

And since this "splitting" could take place again along one of the split paths, you could put your detectors in a place where the photon would "already have had to make up its mind" whether it was going to split or not (before it came to the second split) *but this made no difference to the results.* If you turned the detectors on, the whole photon went down only one path; if you didn't, it split, and half went down each path.

Physicists have thrown up their hands at this. Theoretically, you could keep the splitting going on so that the photon would reach the detector a year after it started its journey, and if you started out the experiment as a "split" experiment and six months later changed your mind and decided to make it a "detection" experiment, you would find that the photon was in only one path. But if you started the "split" experiment and changed your mind after six months, and then changed back again a couple months later (before the photon reached the detector), the photon would be in both paths! Where the photon is depends on what *you* decide; on how you decide to observe it.

And books, like *In search of Schroedinger's Cat* have been written, based on things like this, saying that "nothing is real," and "observation so alters the observed that what we observe depends on our choice of how to observe it."

But this is even more absurd than the experiment itself.

What is the solution? Simple. When the photon is detected, it *acts on* the detector. But a photon can only act *on* something using *all* its energy; hence, if it activates a detector at all, it will appear to be *totally* "where" the detector is.

But a photon can *be acted on* by the fields of its surroundings. And in the case where you focus it into a beam, you are making its surroundings act on it in a special way. Hence, *insofar as it is acted on,* the photon is in *both* paths; but *insofar as it can act*, it can act only on something in *one* of the two paths.

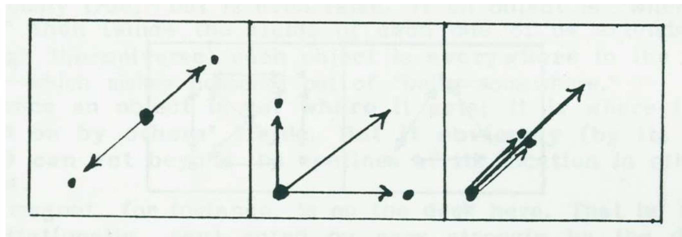
In other words, the photon is in position with respect to the surroundings of both paths; but objects in only one path can be in that funny kind of "position" with respect to the photon itself.

There's no contradiction here. The contradiction arises because we take the naive notion of position ("position-as-I-experience-it") as sacred. If position actually **is** as we experience it, then there is a real contradiction in this experiment; but my theory of position explains it. It also makes sense out of Einstein's theories of relativity.

I rest my case for my wierd notion of position.

—Except to say this: The Mullinstedt experiment with electrons also showed that *objects not in the paths of the electron* could *have an effect* on it. So the electron could be acted on by something that it was totally incapable of acting on, because it was outside the paths that it was "in." This is perfectly consistent with my view of position, and, as far as I know, makes absolutely no sense with any other notion.

4.4.4. Angle There are a couple more topics before we leave off looking at just single forms of energy and get into systems and bodies. First of all, what happens when there are three or four objects with fields? What about a body that is in position with respect to two or three other objects?



DEFINITION: *Angle* is the *combined* distance from two objects to a third.

That is, it is the causality **on** the object in question by *both of the others' fields acting together*. It turns out that their effects on it don't just "add up" in a straightforward way, so that if the force due to the first is two units and the force due to the second is two units, the combined force is four units.

Not to get into the complications of this, but you can see that if the fields are attractive, and the object is **between** the two fields that are attracting it (so that they are on opposite sides of it) the two fields will cancel each other out (it will be attracted equally in opposite directions). If the two fields are on the same side, it will be attracted with the combined force of both; if the two fields are anywhere in between, then the combined force will vary according to the laws of "vector analysis," and the *resultant force* (the combined one) will—in the naive "as-we-experience-it" view—depend on the angle between the two fields.

All I have done here is what I did with respect to distance and position itself; turned the apparent reality around and defined the angle in terms of the *actual effect* of the energies in question **on** the object.

4.4.5. Space Now then, we can consider space itself. I tried hard earlier to show that that imaginary "receptacle" in which things exist is "space-as-we-imagine-it" and has to do more with the structure of our perceptive mechanism than it does with anything "out there."

There are actually two senses in which you can talk about real space: the "space around" an object (which, for instance, is what "gets warped" in Einstein's theory); or "the whole of space." The definitions are rather simple.

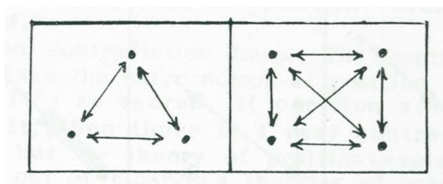
DEFINITION: The *space around* an object is the object's *field.*

That is, the field of the object is what it is that allows you to define *positions* with respect to that object; so it is the set of all possible positions. But positions are "being-affecteds" by that field, degrees to which objects are acted on by it. But that means that the field itself is the reality which is capable of acting-on these possible objects, or is the set of all possible objects **around** the one that has the field.

So the reality of the space around an object is its field.

DEFINITION: ***Space*** **as a whole is** ***the sum of all positions.***

That is, **real** space is defined by all the objects and their position-relations based on the fields of all the other objects. If there were three objects in the universe, the whole of space would be that triangular interaction of the three objects; if four, the interactions of the four:



Since there is a finite number of bodies in the universe, then it follows that *space is finite.* That is, it has a finite extent. In fact, this is one of the conclusions of the Theory of Relativity. Einstein says that space is finite but "unbounded" in the sense that there isn't any "surface" to it. This is perfectly consistent with the notion I just gave of space (though Einstein's is on different grounds, based on the "warping" of the "space around" all objects. I would rather not bring up the complications involved in this; bringing them in would not change the conclusion and would only make things more confusing.)

Well, but if space is a finite "size," so to speak, what is outside it? Nothing. Not space. Just nothing. It expands, by the way. What does it expand into? Nothing—meaning it doesn't expand *into* anything; it just expands. The "space" it would "expand into" is that imaginary space that doesn't exist.

I might point out that, if there are *two sets* of bodies and each set has field-relations *only* with other members of that set and *not* with members of the other set, then there are *two spaces*, and one is *not anywhere* with respect to the other. They would have no position-relation with each other. [This might be the case, for instance, if there is a universe of "anti-matter," which, if it interacted with our universe, would blow it up. "Black holes" are another story; they do have position relations (effects) on objects here; but I leave the physicists to puzzle through what is meant on this theory by "where" they are or we are with respect to them.]

4.5. Action at a distance

One final note. There was an old medieval "first principle" that was supposed to be absolutely certainly true: "Action at a distance is impossible." The grounds for that is that an object is supposed to be where it is acting; and so it is simply a contradiction in terms to say that it can act at a distance from itself.

But what we know of fields shows that this is not only not "obviously true," but is even false. If an object is "where it acts," then (since the fields of each one of us extends all through the universe) each object is everywhere in the universe—which makes nonsense out of "being somewhere."

Hence an object is not *where it acts*; it is where *it is acted on* by others' fields. But it obviously (by its own field) can act beyond the confines of its location in others' fields.

A magnet, for instance, is on the desk here. That is, it is (gravitationally, say) acted on very strongly by the desk, rather more weakly by the back wall, more weakly still by the front wall, very weakly by the side walls and the ceiling, and so on. This is its position with respect to its surroundings, and it can be defined very narrowly.

But it is acting on the compass over on the other side of the room. If it were an electromagnet, you could demonstrate this by turning it on and off and watching what happened to the compass.

It is clearly acting on something which is at a distance from where it is. And, in fact, as we saw, this type of action establishes the only real meaning to distance.

Hence, action at a distance is not only possible; it gives meaning to distance itself.

...Considering that all we have so far considered is the implications of a single form of energy, we have been able to say a few significant things that might turn out to be useful to physicists. Now let us go on to consider systems and bodies.

CHAPTER 5

BODIES AND THEIR PARTS

5.1. Mulltiple units Ordinarily, we do not experience, and in all likelihood cannot experience, a single form of energy in isolation. Energy as we know it always is an act "belonging to" or "produced by" some object, which is what we think of as "really existing." That is, the color of the page is what the *page* is doing to reradiate (or "reflect") certain combinations of wave lengths of the light falling on it; and it is the page which "really" exists; the whiteness is a kind of way it reveals its existence to us.

Note that we speak of the whiteness **of** the page; but the "of" here is used in a different sense from that in the last chapter, where we spoke of "experience-of." Experience-of means "experience about or referring to [something other than itself]"; and act "of" means "an act done by [something other than just itself]."

5.1.1. Sets In any case, energy is experienced as not alone; and there are many different ways of considering multiplicities.

DEFINITION: A *set* is many somethings considered together as a unit.

Obviously, if you are going to think of many somethings at the same time, you have to think of them together somehow; and so the most general category is the set.

Note that the "many" of the set don't have even to be real; a set of ten white unicorns is a set, even though there are no white unicorns. Or the many may be real, but there may be *no real connection* among them, such as the set of all red objects. It makes no difference to any of the other objects that a given member of the set exists or is red. That is, if you dye one of the red objects green, then of course the set has one fewer member; but it makes no real difference to any other member that you did this.

●A *mere* set has no real unification among its members.

Note that the "units" that make up the set are called "members," not "parts" or "elements"; and the members are said to "belong to" the set.

5.1.1.1. A note on why mathematics works

Set theory in mathematics is the logic of the relation "belonging to" and the mathematical set is a mental construct which is the abstraction "whatever is belonged to," and the mathematical member is "whatever belongs to [a set]"; and of course a subset is simply "whatever is belonged to and belongs to."

The "objects" of mathematics are always *created by* the mathematician from the relationship he is exploring, and so never exist as such, and have only the properties of being related by the particular relation. Mathematicians, then, do not *find* objects and *discover f*acts about them (relations they have); mathematics *starts* *with* a relation and explores the implications of the relationship itself by inventing fictitious "objects" whose sole function is to be related by this relation. This helps the mathematician not clutter up his reasoning by properties of the real objects that have the relation (he simply invents a "causer" which is identical with the "cause"). This, of course, is why mathematics is abstract.

The reason mathematics works in the real world is that real objects *are* related in the ways mathematicians explore; and so they will follow the logic of these relationships. The reason that real objects don't behave exactly as mathematics says is not that real objects fall short of the mathematically fictitious "objects," but that they have other relationships which usually interfere with the "pure" working of the mathematical laws.

Thus, the angles of a real triangle never add up to exactly 180º, because the real triangle isn't ever exactly on a plane, and the lines definining it are never infinitely thin, and so on. But *insofar* as the real triangle is a plane figure, then it behaves consistently with the mathematics of triangles.

In other words, what mathematics says about real-world relations is *the truth* and (if it's doing its job) *nothing but the truth*, but not *the whole truth.*

Thus, the reason why certain mathematical constants keep popping up where you wouldn't expect them is that the object is actually related by the basic relationship in question, even though it doesn't seem to be, and this is just one of the aspects of the relation.

For instance, B (pi, the relation between the diameter and circumference of a circle) appears in equations of wave motion. Now mathematically, a wave is describable as the "projection" on the "real plane" of a circle half of which is in the imaginary plane. But waves aren't really going out of space into some never-never land half the time and then simply appearing in the real world. Then what is going on?

5.1.1.1. A note on why mathematics works

The relation pi expresses is *described* mathematically (and was discovered from) the relation between the diameter and circumference of a circle (that is, that the circumference is always 3.14159... times the diameter); but it is actually *part of the logic of anything "cyclic"* or repetitive. Apparently, when you quantify any deviation from something which is such that it "returns" somehow, this number is connected with the deviation-return sequence. So the circle's internal relations are just a special case of a more general relationship (what goes round in a circle returns to itself, describing the circumference); and so we don't have to pretend that real waves are making funny circles somewhere.

Something similar applies to square roots. They were originally discovered by attempting to measure the diagonals of squares drawn as closely as could be to the "abstract square" of mathematics. But what they express is a more general relationship: one of the aspects of the relation between multiples and the multiplied; it turns out that part of this relationship allows for a "multiplied" that is not itself a unit or multiple of other units—and we find this (or an approximation of it) in the real world; and that is why square roots have applications in physics.

So the key to discovering what "mathematical constants" and so on **mean** in the real world is to examine *what the relationship is* that the particular branch of mathematics is exploring; the constant will turn out to be some invariant aspect of that relationship, however it was first discovered historically by mathematicians (who originally thought they were dealing with some kind of "really real" objects in a world better than our own).

5.1.2. Systems But now to return to our multiple units, obviously there are multiplicities we consider together because they *are* connected together. The solar system is not just the set of the sun and the planets; there is the gravitational interaction of all of the "members" of this set that makes them **act** together—so that, for instance, the whole solar system moves together round the center of our galaxy, and its gravitational interaction with Alpha Centauri (the next closest star) has the "center of mass" as the center of the whole solar system, not just that of the Sun. There are, then, certain (in this case insignificant) respects in which the solar system *behaves as* or *acts as* a unit.

But if it acts as a unit, there is a sense in which it really *is* a unit, since existence, as we saw, is activity.

DEFINITION: A *system* is many activities that in some respect act together as a unit.

So there is both a real multiplicity and a real unity in a system. In one sense, a system is a special case of a set: sets are multiplicities thought of as a unit; and systems, since they are real multiplicities, are multiplicities, and since there is a real unification among them, would naturally be thought of as units.

But sets *as opposed to* systems have no real unification among the members; these are the "mere sets" mentioned above.

Note that a system is really very peculiar, when you think about it: it is both really one (it acts as one) and really many (it acts in other respects as many) at the same time. There is a contradiction lurking here, which is a version of the contradiction connected with something's being finite; but we will not pursue it, since that study belongs to the science of metaphysics, not specifically what we are dealing with.

Note also that Immanuel Kant was basically not correct when he put the unification of our experience of systems solely on the side of the perceiver. This would make it impossible to distinguish sets from systems, which we can do. It would also not be possible to account for why we are *forced* to consider some systems as not parts of others (i.e. why you cannot perceive your hand and the book you are reading as a single unit, while you must perceive your hand and your fingers as a single system).

5.1.3. Bodies There are systems whose elements are so loosely connected that they are almost independent of each other. Each stone in a pile of stones does act on the others to some extent—so that the ones on the bottom, for instance, hold up the ones on top. But this interaction is less significant even than the one in the solar system. Then there is the interaction among students in a classroom (in not talking out of turn, and so on), though each is really interacting more with the professor than with the other students. Then there is a social group like a band, where the members have to adapt themselves to what the others are doing, or an army, which is supposed to act as a "unit"; and then there are things like tables, where the pieces of wood are so closely united that picking up one piece means picking up the whole table; and then there are things like dogs, in which the parts don't exist except for their "functionality" in the behavior of the whole. That is, it is "really" the *dog* that bites, not its teeth or mouth.

The point is that the "tightness" of the unification of the elements of the system goes all the way from practically nothing at all to so great that the system is much more obviously "one" than it is "many." And when it reaches this level, we give it a different name:

DEFINITION: A *body* is a system whose unification is so tight that it behaves as a unit more than it does as a multiplicity.

Living bodies are the primary examples of such things; but there are bodies in the world of physics and chemistry as well.

●If a system has activities which are not acts of the elements,

even when together, but rather has acts that are special to it as a system, then it is a body.

For instance, if you mix hydrogen and oxygen, what do you get? Wrong. You get a mixture of hydrogen and oxygen. If you pass a spark through this mixture, or drop a lighted match into it, however, you get an explosion, and—water, which has properties that are neither properties of hydrogen, nor properties of oxygen, nor properties of the mixed gases.

Water, then, is a body.

This would apply, of course, really only to a *single molecule* of water; because "a body" of water has no special properties that don't belong to a single molecule—except those that are explainable by many molecules together. Even the liquid character of water (though it appears only when there are many molecules together) is really traceable to the characteristics of the individual molecule (the way it tends to connect itself with other water molecules).

●In speaking of "bodies" in physics and chemistry, we are really referring to individual units like atoms or molecules. What we ordinarily call "inanimate bodies" are *systems* of many bodies.

●Note that the atoms that make up molecules are *not* bodies (because the molecule is the body), nor are the subatomic consitituents of atoms bodies. A body is always a unit, not a part of another body.

●In the realm of living bodies, the living system *is* a body, since it has many acts belonging to it as a unit.

So things like tables or even pieces of wood, which we would think of as single units are not really "bodies" in the strict sense, because they have no real activities that are distinctive to themselves as units as opposed to being simply a sum (or system) of their parts.

With a piece of wood, for instance, if you break it in two, both pieces are still what they used to be; and if you keep doing this, you still get smaller pieces of wood—until you get down to the individual molecule. If you "break" this, however, you get something that isn't wood at all. So this is the body; the piece of wood you can see is a system.

However, if you "break" a dog apart, you get something that isn't a dog at all, and behaves quite differently from a dog. So a dog is a body. So is a plant. If you cut off a branch from a tree, in general it dies, and behaves quite differently from the way it did while a part of the tree; hence, the tree is a body.

DEFINITION: A *member* is one of the units in a *set.*

DEFINITION: An *element* is one of the units in a *system.*

DEFINITION: A *part* is one of the units in a *body.*

There is nothing profound about these definitions; they are simply the way we usually use the terms—and in ordinary speech (and sometimes in science, too) we are apt to use them interchangeably. The reason for this, of course, is that the distinction between a "mere" system and a body has a basis in fact, but is in a sense arbitrary; and when you get into borderline cases, it isn't obvious where the line dividing them is.

I have made the line seem perfectly clear: if there are acts of the unit as a whole that aren't explainable by the parts as connected. But in practice, this doesn't work out so neatly. Is a crystal a body, for instance, or is it a system of molecules? You could argue either way. I incline in the direction of saying that it is a system, myself; but that is really more my preference than any conclusion forced on me.

And in the last analysis, the body is really just a very tightly bound system—and in that sense, it isn't really a different sort of something from a system itself (the way systems, as really unified, are different from "mere" sets that have no real unity). So it isn't surprising that there should be differences of opinion on where "mere" systems end and "true" bodies begin.

But on the other hand, it is silly to make *no* distinction between the two, and say that there isn't any real difference between a pile of rocks and a dog. The extremes are so extremely different that they don't deserve to be put in the same class; and hence, the difference between systems and bodies is valid.

●There is a tendency of physics to consider bodies as systems, whereas chemistry is more apt to consider bodies as units.

This is just a tendency, not something absolute. But physics tends to look at how the parts of a body are connected—the internal forces—while chemistry tends to look at how bodies become different kinds of bodies when certain things happen to them. Chemistry doesn't *ignore* internal forces, nor does physics pay no attention to the "newness" of a larger unit as a unit; but the basic orientation or focus is as I mentioned, and can explain some of the differences in approach between physics and chemistry.

5.2. The body and its parts

Much that I am going to say from now on will apply both to bodies and to systems. I could treat systems and then bodies; but since they are essentially the same sort of reality, differing only in degree of unification, this would involve either a lot of repetition, or would give the impression that systems are the "primary" sorts of things, and bodies are a kind of "second-class" type of system—when it seems to me that the best description of things is the other way round.

Hence, I am going to talk about bodies, and only mention systems in passing, when there is some need to distinguish what happens in a system from what is going on in a body; in other cases, I leave it to the reader to make the adjustment based on the fact that the body is *primarily* a unit and *secondarily* a multiplicity, while the system is the opposite.

Let us first make the a couple of obvious remarks about what is necessary for a body to be a body, and then explore these remarks in detail.

●**A body has *one fundamental activity* making the parts behave together as a unit.**

That is, the body, as a real unit, has to have an *internal cause* of the unity of the many parts. And since existence is activity, then this means that the parts have to *act together* as a unit.

●**There have to be *many* parts for something to be a body.**

This is obvious. If the "body" is simple (a single act) then it isn't what we are calling a "body" at all, however "material" that act might be, but is simply a single form of "free" energy. Such an act (if there is one) could not be considered a special case of a system, and so would be completely describable in the context of the preceding chapter, and would need no further discussion. What we are considering as "bodies" are *multiple* units.

●**The parts of a body are not necessarily themselves simple. They**

may be *subsystems.*

The "ultimate" parts of a body, perhaps, are single forms of energy; because logically, if the parts are complex and these subsystems (i.e. the parts) are complex, eventually you would have to get down to some subsystem whose elements were not complex—and it would seem reasonable to say that these "ultimate" elements are just single forms of energy. For instance, the parts of a salt molecule are a sodium atom and a chlorine atom; the sodium atom (**as** a part of a molecule) is a system of a certain number of protons, neutrons, electrons, and so on, unified in a certain way; and the protons are perhaps systems of quarks unified in a certain way; and the quarks (if there are such systems) are unifications of certain forms of energy: the "carriers" of the strong force, whatever accounts for "spin" and so on—if indeed these are real forms of energy. When you get down this far into the elements of a subsystem of a body, it is very hard to tell what you are actually dealing with.

In any case, it is not necessary to regard only the "ultimate" parts as the parts of the body. Subsystems interacting in definite ways with each other will do nicely as the parts. Thus, your heart is a part of your body; and it is made up of cells of a certain type unified in a certain way (for a certain function in the body as a whole); and so the cells are "more ultimate" parts, if you will; but even they are very complex systems of molecules, and the molecules are extremely complex systems of atoms, and so on.

●It depends on the focus of the investigator what is to be considered a "part" of a body.

There is nothing wrong with considering a body as a unification of various *systems of organs,* such as the circulatory system, the digestive system, and so on. In this way of considering the body, the systems of organs are the "parts" that make up the body. On the other hand, you can consider the body as made up of the organs themselves: the heart, the veins and arteries, the stomach, the intestines, the eyes, the brain, and so on; and from this point of view, the organs are the "parts." If you want to consider the body as a unification of cells, then the cells are the "parts," or as a unification of organic chemicals, then the molecules are the "parts." And so on.

No one of these ways of considering your body is "the right way." Your body, for instance, is *not* "just" a unified collection of chemicals—as if you go from the chemicals (which, on this supposition, are the "real" parts) right up to the whole, without passing through the unifications into cells, organs, and systems within the body. On the other hand, there is nothing *wrong* with considering the chemicals as parts of the body, as if the organs, say, were the "real" parts and the chemicals that make them up were not really there.

The reason that there are disputes about what the "real" parts are (which would seem—and is—silly) is the following fallacy:

●**The *system-fallacy* is the consideration of a body as "really" a mere system: considering the *parts* as what it "really is," and the *unification* as "secondary."**

In a body, remember, it is the unity which is primary; the parts are secondary to the unit, not the other way round.

This is most obvious in living bodies. The organs and so on in a living body are "functional": that is, they exist *for* (in some real sense) the *activity the body as a whole can perform* because of them.

As Aristotle said, "We do not see because we have eyes; we have eyes in order to see." This can be shown by the fact that the living body *controls* the acts its organs perform; we close our eyes sometimes, preventing them from having their "proper" function, when we think the body as a whole should not be seeing. We even remove parts of the body when they get in the way of the functioning of the body as a whole—such as fingernails when they grow too long. This indicates that the whole is **not** a kind of "aggregation" of the parts which are what is "really all there is to" the body; but the *whole* is what is "really there," and the parts are subordinate to it.

In this connection, think: you don't (because basically you can't) regard yourself as a "really" bunch of organs that are acting on each other. When someone hits your back, it was *you* he hit *in* the back; he didn't hit the back, which then "reported this" to the brain as if the brain were someone it was telephoning.

This is hard for the "accidentalists" to swallow. Ever since Darwin and the survival of the fittest, there has been the tendency among scientists to consider that evolution has been "explainable" completely by chance—and so the bodies we have are just accidents of natural selection, from which it follows that the parts are what are primary and their unification an accidental accretion. That is, the logic of this way of looking at things is that we see because (in the course of evolution) we acquired eyes, not that we have eyes in order to see. That's old-fashioned unscientific superstition, they think

The trouble with this view is that it supposes that chance can explain something. But, as we saw in discussing the Laws of Probability, the **chance** element in what behaves probabilistically *explains nothing at all about the probabilisitic behavior*. It is what is *non*-random about the system or body in question that gives the *rational* (i.e. explanatory) element to probabilistic behavior.

Hence, evolution is by no means "just chance." It **involves** chance; but the *structure* of the evolving organism *opens up* certain possibilities, which are then *realized* at some given time by chance. But the possibilities are not realized *by* chance; they depend on (a) their being realizable in the thing that is evolving and (b) there being a trigger-mechanism in the environment capable of realizing them.

5.2. The body and its parts

The only thing that is "due to chance" is *when* this trigger will activate the possibility in the evolving body.

On such a flimsy thread does the scientist's materialism hang.

●*Beware*, therefore, **of considering the parts of the body as what is "really" real about it.**

●*Second caution:* **The forms of energy that are the *behavior* of the body *are not its parts.*** These are ways in which the body behaves *as a whole*, and are not what it is "made up of."

That is, color, mass, shape, motion, elecrical fields, and so on (the things we normally call "properties"—as we will technically call them later) are not parts of the body, but ways in which it *acts* (as a unit of many parts). We will have to discuss the body and its properties later, after we have considered the body and its parts more closely.

5.2.1. The unifying energy

Let us now look a little bit more closely at the activity that is the cause of the unity of a body. We said that it had to be *one* activity; and the reason for this is that if there were two of them, they would either be really independent of each other, or they themselves would be connected by some activity. In the latter case, of course, the cause of the unity would be this "connecting" activity (as indeed happens in bodies made up of subsystems); in the former case, the "body" would behave as two independent units, because there would be nothing to give it a **real** unity. Hence, what makes the body behave as a unit must be one single activity.

5.2.1. The unifying energy

●The activity that unifies the body is *not directly observable* from outside the body.

That is, whatever this activity is, it is *not* one of the properties (the "behaviors") of the body that you can get at from outside it. Why is this? It is by definition whatever accounts for the *unity* of the body. Hence, its function is *to connect the parts into a unity.* If it acted outside the body, then it would obviously be connecting this external thing it acted on into the body—making it part of the body. But this is absurd, since then the external thing would not be external.

Further, since the unifying activity, whatever it is, makes the body a unit, then it follows that *it is the activity which is ultimately responsible for excluding from the body whatever is "foreign" to it.* Hence, it not only keeps the parts together as a single unit; it keeps everything else out of the unity.

Therefore, the activity unifying the body is exclusive to the body, and is not directly observable from outside. You have to *argue* that it is there from the way the body behaves (i.e. as we did above: that it has properties that belong to it as a unit, and aren't explainable just as a sum of the parts).

●The activity unifying the body is a form of *energy.*

This would naturally be expected, if the parts themselves are bundles of energy and ultimately energies. But you can argue to it this way:

A) Bodies with (for practical purposes) the same parts act as units in different *ways*, so that we recognize them as *different kinds of bodies.* Thus, dogs and cats have the same ultimate parts (the same chemicals in the same amounts, more or less, and in the same proportions; or even for practical purposes the same cells; obviously, at the level of the organs there is a difference). Then the difference is not (ultimately) *what* is unified, but *the way in which* it is unified.

True, the genetic chemicals *determine* the way in which the body is ultimately unified; but (1) these chemicals are basically a *way in which* the atoms are unified; and (2) there are differences which determine only different individual dogs, not different species; and so the differences in chemicals have to determine a *different basic kind of unification* of the body as a whole in order to determine different species.

● So the conclusion from A) is that **the activity unifying a body is a *form* of activity.**

B) But there are bodies *of the same type* which are made up of the same ultimate parts, but yet are *different* from each other.

For instance, there are different dogs, even of the same breed; they have different colors, different degrees of alertness, and so on. Now the *form* of the activity unifying the body can't account for this; because it accounts for how all the bodies are *the same* (and different from cats); nor can the *parts* account for it, because all the dogs have for practical purposes the same parts.

● Therefore, the **form of activity unifying the body must be limited in *degree*,** which means that **it is a form of *energy*.**

Conclusions we can draw from this:

●**The *form* of the unifying energy of the body is what accounts for the *kind of body* which the body is.**

That is, the form of the *body* is the form of the *unifying* *energy* of the body, not the form of some part or parts.

And since this unifying energy is (as we saw) not observable from outside the body, it follows that there is no *direct* way to know whether a body is a given kind of body or not. It must be argued to from (a) similarities of substystems (larger parts), and (b) similarities of behavior as a whole.

That is, if an animal has organs that are *significantly different* from another animal, this argues that it has a different *form* of unifying energy, and is a different kind of animal. Why else would the organs be different? This would be confirmed if the *behavior as a whole* were significantly different.

Thus, a cat has different sorts of organs from a dog, and a cat doesn't act (as a whole) like a dog. Since we can't observe the unifying energy directly, we use these two as clues to tell us that cats are different kinds of things from dogs.

But note that this means that a caterpillar is a different *kind of body* from a butterfly, even though the caterpillar turns into a butterfly. Its body has different sorts of parts, and its behavior as a whole (it eats leaves, while the butterfly eats nectar) is significantly different. Hence, the *kind* of body is *not* coextensive with the *biological species.*

(For those interested in the application of this to the abortion question: First, the issue of whether a fetus is or is not a human being will never be settled by direct observation, but can only be got at by inference—since it is the form of the unifying energy of the fetus's body which would make it a human being. Second, the fetus is not part of the mother, since the fetus does not act for the mother's benefit, but its own—it takes nutrients and can make the mother sick, while it develops normally, for example. Third, the fetus is not like a caterpillar as opposed to a butterfly, since it develops organs from the beginning which are not adapted to its life inside the uterus, but its life outside. It also performs very soon—within a couple of months of its nine-month stay—actions which make sense only in its life outside the uterus—breathing, swallowing, thumb-sucking, etc.. But since the parts and the behavior indicate the form of the unifying energy, this means that the fetus is already a human being from the beginning.)

●**The *quantity* of the unifying energy of the body accounts for there being *different individuals* of the *same form* of body.**

Just as the **kind** of body depends, not on the parts united, but the form of the unifying energy, so individual differences in bodies of the same type depend, not on the parts united, but on the degree of the unifying energy.

That is, different dogs (of the same breed, say, ignoring whether differences in breed imply different forms of unifying energy) are different, not because they have different parts in their bodies, but because they *exist at different energy* ***levels*** for this kind of unification of body-parts.

To put this another way, what it amounts to is that the form of unifying energy called "dogness" *is itself limited*, as heat is or mass is, and so on, so that no individual dog exhausts "what it is to be dog"; one dog can always do doggie acts that other dogs can't and vice versa: pit bulldogs can bite and hang on in ways that schnauzers cannot, and greyhounds can run better than other dogs; and so on. There is no such thing as "the absolute dog" any more than there is such a thing as "absolute heat" that is not some temperature of heat.

(It should be noted in this connection, however, that human beings *have control* over the level of limitation of their humanity to some extent, and can—by choosing—perform activities or refuse to perform activities that make them different from other human beings. This control over one's individual differences from others is called **self-determination,** and it is different from what you find in the objects that physics and chemistry deals with. Individual differences which are "built in" to the unifying energy by its given quantity are called **individuation** within the kind of body; individual differences which are due to choices are called **individuality** of the person in question. The two are similar in results; but the *source* of the individual characteristics is different.)

5.2.2. "Matter" This brings us to a concept that was originally philosophical (the term is Aristotle's) and is used in science, but with a not clearly defined sense: matter.

"Matter," of course, is whatever it is by which things are "material," or are bodies. It is clearly the opposite of "spiritual," from which we can infer that spirits aren't bodies. We usually think of material things as "solid," but there are things like gases which don't fit that notion and clearly are not spiritual. Interestingly, when something is material, it is "there" (i.e. exists in a place), while spiritual things like ideas don't seem to have a location (the idea we share that 2 + 2 = 4 is one idea, and so is not really somewhere "in" my head and yours, let alone "between" it).

In physics, "matter" means either (a) a body (as when the physicist talks about the "propagation of light in matter") or mass (as when he talks about "the conversion of matter into energy). Mass, however, is one of the *acts* of a body, and a body itself is different from its acts. The two senses of the word are actually incompatible, even if related. Hence, "matter" is not a technical term in physics; it is just one of those words "everyone is supposed to know the meaning of."

If "matter" is what makes a body a **body,** then it follows that

DEFINITION: *Matter* is the name given to the *quantity* of *unifying* energy.

• NOTE •

In writings after this book was originally written, I do not use the term "matter," which is why it is in quotes in the section title. I simply talk of the quantity of the unifying energy, without giving it a special name. Calling it "matter" makes it sound as if it is some kind of "stuff," which in my system (and that of St. Thomas Aquinas) it is not. But I will keep it in this book for historical purposes.

Quantities, as I said in the preceding chapter, are not all exactly the same. All are limitations of forms of activity, but the quantities belonging to one form are only analogous to the quantities of another form.

And this is recognized in science by giving the quantities special names depending on the form they are quantities of. Thus, *temperature* refers to the quantity of heat, *charge* the quantity of electricity, *mass* the quantity of gravitational energy, *wave length* the quantity of electromagnetic energy, and so on.

If the energy is unifying energy, its quantity is called *matter*.

The reason for this is that something is a body if it is (a) not spiritual, and hence has not only the limitation of form, but that of quantity as well, and (b) is a unified multiplicity, implying that it has a unifying activity. But the unifying activity is what defines the thing you are dealing with (its form defines what kind of thing the body is, and its matter defines its individuality within the kind). Hence, the "bodiliness" of the body is due to its unifying activity—and it must be due to the fact that the unifying activity is not spiritual, but has a quantity.

5.2.2. "Matter"

Therefore, the "matter" that makes the body material is precisely the quantity of the unifying energy—which is what our definition says.

This also is consistent with the original usage of the term. Aristotle mentioned that matter is what is responsible for there being different individuals of the same type of thing; which is exactly what matter in the sense above does.

Aristotle, however, thought of matter as some kind of "stuff," undefined in itself, which acquired a form: as a kind of "ability" to have a form. He was thinking backwards, as can be seen from the fact that he thought that form limited matter, when the facts are the other way round. Matter, as the name for a generic *limitation* is not itself limited, because it is the abstraction of limitation. Aristotle mistook this abstraction as "non-limit" (as existence is unlimited in itself); and that was why he was fooled.

That is, just as the concept "temperature" does not point to any definite temperature, but applies to *any* limitation of heat, you can see that, if you wanted to look at temperature in a peculiar way, you could say that temperature was "unlimited" until it "received" a heat, which then made it a definite temperature of heat. Since Aristotle thought of matter as a kind of "stuff" (bodiliness in general), he was thinking of what was actually a limitation in just this peculiar way.

●**BEWARE,** therefore. **Matter is not some *"stuff"*; it is simply the *degree* of the *unifying energy* of a body.**

That is, matter is *nothing more than* the strength of the internal force—if you will—uniting the parts; the *kind* of force is the form of the unifying energy, and the *degree* of this force is the matter. Bodies are bodies because they are unified to a certain degree as well as in a certain way.

●Note that there is *not* just *one* matter. There is one matter (at a given time) per body; but there are an *infinity* of possible matters for any given form of unifying energy.

Again, thinking of matter as one something is thinking of it as a "stuff" out of which material things are "made"; but what it really is is like the temperature of unifying energy; and there isn't a "temperature" that heat is "made of," nor is there just one "temperature"; each case of heat has its own definite temperature, and there are an infinity of possible temperatures for heat. Thus, each form of unifying energy has its own matter, and there are an infinity of possible matters for unifying energy in general.

What Aristotle called "primary matter" (though he did this only once in his writings) and the medieval philosophers referred to often is simply this abstraction of matter analogous to the abstract notion of "temperature." The medievals correctly saw that matter was the limitation of the form of the unifying energy (which they called "substantial form"); but they were so filled with this image of matter as a kind of "stuff" that they didn't see the inconsistency in what they were saying in talking of "prime matter."

So once again: beware! Matter is **not** a "stuff"; it is simply the degree of the unifying energy; the basic energy **level** of the body as a unified whole. It is a limitation **of** something, not a "something."

5.3. The unifying energy and the parts

A body, then, is a number of parts connected by a unifying energy. Having established that the unifier of the parts is energy, and having defined its quantity as matter, let us look at what is happening (as far as we can infer) between this energy and the parts it is connecting.

●**The unifying energy is nothing more than the interaction of the parts themselves.**

That is, the unifying energy is *what the parts are doing to each other;* it is *not* something "separate" added to the parts.

Or to put this another way:

●**From the point of view of one of the parts, the unifying energy is the *force* this part exerts on the others and the force the others exert on it.**

That is, from the point of view of one of the parts of the body, the body "appears" as a system, and the unifying energy appears as a *set* of forces connecting the different parts. This would have to be the case.

Hence, the form of the unifying energy would appear as the *type* of force connecting the parts, and the matter would appear as the total strength of these interconnecting forces.

But how can one unifying energy be many forces? Because this one energy is the one that *pervades* the body, making the parts behave together. Hence, each part is connected to the others by this unifying energy, and so from its point of view, it is a unit connected to others by many forces.

The reason this sounds contradictory is that we are here into the peculiar aspect of the body which is its multiple unity: what makes it a unit appears as a multiplicity to the sub-units within it, while these sub-units are a multiplicity which disappears, more or less, in the unity of the total.

●**Each of the parts, if it is itself a multiple unit, has its own unifying energy; but this unifying energy is *ssubordinate to* and *governed by* the unifying energy of the body as a whole.**

This must be true, because the body is primarily a unit; if the parts were "really" bodies, and only connected to the other parts, then we would have a "mere" system and not a body.

Therefore,

●**The unifying energy of the body as a whole is also *within* the parts.**

Thus, even though the unifying energy appears to a given part as a force connecting it with the other parts, this force *makes a difference to its nature*, so that it is not the same outside the body as it is in the body.

●**The part *has no real identity* except in relation to the whole** i.e. as a part of it. It is not the same as it would be if it were a unit in its own right.

Thus, for instance, when two hydrogen atoms and an oxygen atom combine as a water molecule, the oxygen atom no longer exists as such; what exists is the *water molecule*; the "oxygen atom" is now a *part* of the molecule, and it has a *different configuration* from what it would have as a free atom, it has less energy than it would have as a free atom (the water molecule has **less** total energy than the sum of the atoms taken separately—which is why there is an explosion (energy given off) when they combine. The electrons form a shell of strange shape around the whole molecule now, not the individual "atoms" in it.

The result is that if you were to split this molecule apart, and get two hydrogen atoms and an oxygen atom, *you would not get back the same atoms you put in*. That is, the atoms would not (in all probability) have the same electrons they had before. You would get "the same" atoms in the sense in which, if you exchange four quarters for a dollar, and then change the dollar back into four quarters, you get "the same" change you started with—but not necessarily the identical quarters you gave in the first place.

The point is that the oxygen as such vanishes or goes out of existence when the oxygen atom becomes a part of a water molecule; the location of its nucleus is identifiable in the molecule, but the oxygen as a "whole" is *behaving in a new way*, and is not really a whole now; the whole is the water.

●The unifying energy can be considered the *configuration of the internal space* of the body.

Remember that the space "around" something is its field, and that space in the other sense is the field-interactions of the bodies in it. But the unifying energy of a system is what the parts are doing to each other; and so it is the relations among the parts as internal to the body; and so it is the body's real internal space.

And this is confirmed by the fact that, say, a proton has an electrical field which extends out to infinity; and so does an electron. But if the proton and the electron interact (and the electron is "bound") what we have is a hydrogen *atom,* (a body), and *the electrical fields change shape, so that they are now a single field internal to the atom.* That is, put another electron near the atom, and it has no idea that there is a proton anywhere around—because the proton's positive electrical field has been "neutralized" by the electron it is bound to, and is "tied up inside the atom."

Hence, the unifying energy of the hydrogen atom is in one sense the electrical field; but it is not simply an electrical field; the electrical field in the atom has changed its nature, and is now a different sort of configuration of space: one specific to hydrogen as such.

Physicists are fond of saying that there are three or four "basic forces" of nature (the "strong force" binding the parts of the nucleus, the "electromagnetic force" binding the nucleus to the electrons, the "gravitational force" we all know, and the "weak force" that is quite mysterious), and they talk as if everything is just a kind of accidental summation of these forces as if they are what "really" exists.

This is another version of the fallacy I mentioned above. These "forces" are what they are only if you consider the bodies united by them as systems, not bodies. And the point is that they behave differently depending on what body you are talking about.

For instance, the "electromagnetic force" is the unifying energy of a hydrogen atom; but there is no new force uniting two hydrogen atoms into a hydrogen molecule. But the fact is that the shape of the internal space of the hydrogen molecule is different from that of the atom.

This "shape of space" is not *accidental* to the "electromagnetic force"; it **is** that "force." The "force" has no other reality except to **be** the interaction between things; and so it is the (real) space between things. But this means that the *form* of the unifying energy of the molecule is *different* from the form of the unifying energy of the atom; the atom does not behave as an atom any more, but differently; it is not simply "connected" to the other one; it has lost its identity, and what exists is the molecule. The same is true of the electrical interaction of the parts of the molecule; this is *different from* the electrical interaction of the parts of the atom; and the name "electrical" is an *analogous* word used to indicate that if you break up the molecule, you get out atoms again.

So what is "really" holding the molecule together is **not** "really the same" as what is holding its atoms together. The *shape* of the internal space *is the primary aspect* of the unifying energy; and it is what makes the body a molecule and not a collection of atoms.

The point here is that a body is **not** "really" a collection of its parts that happen to be connected (just because you can get bodies like its constituents if you break it up), nor are the "forces" connecting the parts "really" just something external to the parts themselves. The body is *primarily* a unit, defined by the *form* of the interaction of the parts; and this form is specific to each type of body, and is the internal space of the body.

5.3.1. Newton and Einstein

It turns out that the argument I just gave applies to a lesser degree even to systems which are not single bodies. One of the major differences, in fact, between Newton's gravitation theory and Einstein's General Theory of Relativity is actually connected with what I have just been saying.

Newton considered the solar system as a system of bodies connected by forces (the gravitational forces) more or less "external" to each body—at least in the sense that the force was a "behavior" of the body towards the other bodies it was connected with. Hence, if you wanted to consider the motion of the earth around the sun, you calculated the strength of the force connecting the two, and supplied the "initial tangential velocity" which made the earth not directly fall into the sun. This gives you the basic orbit. Then you calculate the force connecting the earth, say, to Jupiter, and the motion of Jupiter around the sun (so you can see how this force changes as the distance between the earth and Jupiter changes), and you add this to your calculation to get the "perturbation" of the basic orbit. Do this for all the other planets, and you should come up with the actual orbit.

But you don't.

If you look closely at what the General Theory of Relativity is doing, however, you notice that its "warping of space-time" in the presence of massive objects is considering the field, not as a *force* connecting objects, but as a *configuration of space itself,* and in this space there are certain "energy levels." The earth, being on one of these "energy levels," follows or stays on this level, which is a kind of "shell" or "path" around the sun. Now the energy level is affected by the massiveness of the other planets, which are at other "energy levels" in the basic "space-warp" of the sun (which, because it is so massive, does most of the "warping"); and you can predict what the orbit of the earth will be because you know what the *shape of space has to look like* that it travels along.

And this works.

In other words, Einstein was considering the solar system more like what I said is true of a body than of a system of interconnected bodies; and his description of what the "parts" of this "loosely bound body" are doing is more accurate than Newton's description of the same events looked at as a system of bodies that happen to be connected together. And it is not that Newton's numbers were off in calculating the "gravitation constant" of his force. There is no changing the strength of the force known that will give you the exact orbits of the planets; in order to get the exact orbits, you have to take a different point of view, and say that they are like parts of a body which has a certain internal space-configuration.

Now of course, the difference between the two approaches works out to be very very small; Newton is off by an almost unmeasurable amount—because the solar system *is* a system, and the gravitational interaction of the planets is by no means their most important aspect. But it is significant that even here, you are only perfectly accurate if you consider the shape of space rather than interconnecting forces.

5.3.2. Some predictions

This seems to be an indication that my interpretation of bodies and their unifying energy is on the right track.

●**I now offer the following prediction** from this philosophical

5.3.2. Some predictions

view:

The way I described what Einstein was actually doing was not exactly how he would have described it; and it looks suspiciously like certain ways of describing the atom in quantum mechanics. I predict that if this way of looking at things is pursued more closely (i.e. that of considering the solar system as a kind of body with internal "energy levels" on which you find the planets), then there might be fruitful analogies from quantum mechanics, which might possibly explain why the planets are arranged according to Kepler's Third Law (which no one knows what to do with), and why their masses are what they are (because certain masses must be a certain energy-levels in the space, perhaps), and so on.

That is, when the solar-system-atom analogy has been used up to this point, it was the solar system that was the model and the atom was described in terms of it as a kind of little tiny solar system. This didn't work very well. What I am proposing is to turn the analogy back the other way, and use the atom as the model for describing the solar system. I think Einstein has (advertently or inadvertently) made a start on just this; and so my prediction is that if you pursue it consciously, then the results should be fruitful—and it could be that here you would find the long-sought integration of classical, relativistic, and quantum physics.

I would not say that if these hoped-for results fail to materialize, my theory is wrong—because the solar system **is** a system, not a body (as the atom is); and so the analogy might not work. But if breakthroughs in considering the solar system should occur because of this, I think this would be a confirmation that my philosophical view is really a description of what is really going on.

●I offer a second prediction:

Differences in the "basic forces" of nature may very well be describable in terms of *different geometries.*

People have been recently looking for "magnetic monopoles," (i.e. a "north" pole that doesn't have a south pole attached to it) and have been in a quandary that gravitation doesn't have a repulsive component.

If, as I predicted above, the unifying energies of nature are describable as configurations of space, then it would not be surprising to find that the geometry of a magnetic field and that of an electrical field are different (as they clearly are, because of the "bipolar" aspect of magnetism). My prediction is that **each** unifying energy is **its own** special configuration of space, and the differences are to be expected rather than explained away.

That is, what this theory of unifying energy says implies that Einstein was probably on exactly the wrong track in his search for a "unified field" theory; and, if my view here is true, it is not to be wondered at that he couldn't find it. If you will, my view predicts a "diversified field" theory, with Einstein's General Theory of Relativity describing the *gravitational* field; but a description of electrical field interactions would imply a different non-Euclidean geometry; that of magnetic interactions still a different one; that of the "strong" force its own special geometry, and so on. The hydrogen atom's internal interactions would also be describable in a special geometry of its internal space, the oxygen atom's in its special geometry; and what is called the "chemical bond" would be describable as a new geometry of the internal space of a molecule.

Let us let this be enough for a philosophical description of bodies and the relation of the parts and the unifying energy; but there is still the question of considering the body and the acts it performs **as** a whole body.

5.3.2. Some predictions

CHAPTER 6

BODIES AND THEIR PROPERTIES

6.1. "Substance and accident"

I think I should begin this chapter by bringing up something historical, and stating why I am not going to use the terms "substance" and "accident" in describing bodies and their properties (or the way they behave).

Aristotle, who lived around 350 B. C., was the originator of the theory, and indirectly of the terminology. He spoke of what he called the "reality" and its "accompaniments," and referred to the "reality" as the "primary activity" and the "accompaniments" as "secondary acts." What he was talking about, generally speaking, was our notion of "body" (though he would class spirits with "reality") and the various ways the body behaves—which we are about to discuss.

As to the body and its parts, his theory was that bodies were continuous things (i.e. with no internal "spaces" between parts), made up of various mixtures of the four "elements" of earth, water, air, and fire. The "matter" was the ultimate "stuff" underneath the elements, and was the pure ability to do the "primary activity." This primary activity took on various "aspects" or "forms" and gave the matter (and the body) its type.

With Plotinus, around A. D. 250, it was realized that matter was the limitation of the form of the "reality"; but of course, the matter was still not looked at as a quantity of unifying energy, but as a kind of "stuff"—though, interestingly enough, even at this early stage, it was connected somehow with space.

When the Greek terms got translated into Latin, "reality" (for complicated reasons) was translated as "substantia," which means "what stands underneath [the secondary acts]" and the secondary acts were translated as "accidentiae," which means "what attach to or accompany [the primary act]"; and so we have "substance" and "accident." "Accidents" were then classified as "proper" if they had to be present when the "substance" (which means what we mean by "body") was; thus, speech is a "proper accident" of human beings. Other accidents, however, might or might not be present when the substance was—as blackness or whiteness is not a proper accident of a human being, because you can be either and still be human.

Not to make this too long a discussion, the notion of "substance" was doing double duty in explaining the relation between the body and its parts and the body and its "accidents." In the first case, the "substance" (like our unifying energy) was internal to and private to the body; and it **seemed** separable from the "accidents." In the second sense, however, the "substance" meant "the whole body" (in relation to how it behaved).

But by the time of Descartes, in 1600, the general way of thinking was that the substance existed "in itself" and was therefore independent of its "accidents" and remained unchanged when they changed. This was a gross misinterpretation of Aristotle's original theory, and of the great commentators on it like St. Thomas Aquinas. "Substance" was looked on (and criticized by John Locke as) a kind of "pincushion" you stuck the accidents into.

The definition of "substance" as "independent" led to all kinds of aberrations. Descartes thought that the human being was two different substances, mind and body, because the concepts of mind and body were independent of each other. Spinoza shortly after thought that only God was a "substance," since everything else depended on God; Leibniz, around the time of Newton (say, 1700), thought that each atom (if you will) of a body was totally independent of everything, and they could not act on each other, because that would make them dependent and not "substances." Kant, around 1800, held that when we observe something, our minds unite the sensations of it into a single whole, and we create the "substantiality" of it by our unifying of its effects on us.

Not surprisingly, philosophers nowadays shy away from the notion of "substance"; but in so doing, they have also shied away from the effect Aristotle and the medievals were trying to find the cause of. We have, I think, got through all the silliness which was the product of Descartes' attempt to deduce the world from the contents of consciousness; but the notion of "substance," which was a mistranslation of Aristotle to begin with, has been so battered in the process that I don't think it serves any useful purpose to try to resurrect it in its original usage.

The term has, however, a legitimate usage still in chemistry; and so let us define it to fit this usage:

DEFINITION: A *substance* is a *kind* of body.

Thus, a given human being would be a body of the human type, and the "substance" would be "human." Sulfur, for instance, in chemistry, is a substance, as is water or carbon or hydrochloric acid. A given atom or molecule of sulfur or water or hydrochloric acid would be one atom **of** the substance in chemistry's or our new terminology, but would not be "a substance" (though it would be one in the medieval sense of the term).

●The *form* of the unifying energy determines the substance one is dealing with.

This is actually tautologial, once we have defined "substance" in the way defined above. We saw that it is the form of the unifying energy that makes the body the kind of body which it is; thus, it is the form of this energy that defines what substance you are talking about.

Whether this notion of "substance" turns out to be philosophically terribly useful, at least it is such that philosophers and chemists are saying the same thing when they use the term; and that is an advance over what we have now.

6.2. Body and property I am also going to avoid using the term "accident,"which to us means "something that didn't happen on purpose" instead of "what accompanies." I will replace it with the term "property," which was the short form of "proper accident"; but we must make the following qualifications:

DEFINITION: A *property* of a *substance* is some activity that a body does because it is the *kind* of body which it is.

DEFINITION: A *property* of a *body* is *any* act that the body performs as a body.

Thus, my writing this sentence is a property of me as a body, but not as a substance, since you can be human without writing this sentence. But in a sense, I can't be the self I actually am without writing this sentence—because in fact I am writing it (and so am "the body that is writing this sentence").

This gets us free of the notion that the behavior of a body is "accidental," as if it could come and go without the body's being any different. *Any* behavior of a body is a property *of that body*, whether or not it is a property of that substance.

6.2.1. The property itself Let us now try to examine the relation of the property to the body of which it is the property. First of all, we can say this of the property itself:

●A property of a body is always an activity.

This would have to be true if the property is not imaginary, or something we impose on the body (as we might impose a "coordinate system" of some type on it in order to study its movement. No one supposes that the coordinate system is actually in the body itself; it is just a convenience we use to consider something about it). If the property is real at all, it is either an activity or a limitation of some activity. But since we know the body *through* its properties, then they are acts, not limitations. [In fact, historically, the "substance" (in the sense of the body) was looked on as a kind of "power" to perform its acts, and as a sort of limitation of them analogously to the way matter is the limitation of form. In any case, the property is an **act,** not a limitation.]

●A property of a body would always have to be some form of activity.

Clearly, infinite activity could not be a property *of* something, because it would have to be distinct from what it was a property of—which would mean that it would have to be somehow different—not to mention that it would have to be subordinate to the body (as we will see) to be a property of it, which is absurd in the case of Infinite Activity (on which absolutely every limited activity absolutely depends). Hence, a property has to be limited *at least* in form.

●It is not *necessary*, however, that a property also have a *quantity*; but if it does not, this argues that the unifying energy of the body is somehow not quantified either.

I bring this up because it turns out that human bodies do perform properties (thinking and choosing) that cannot be forms of energy (i.e. have no quantity and so cannot in principle be measured). The evidence for this is found in my book, *Living Bodies*, where I also show how this argues that the unifying energy of the human body is basically not energy but has a quantitative "dimension" which is not necessary to it.

Generally speaking, however, properties of bodies will have definite quantities, and so will be forms of energy.

●When a property is measurable (has a quantity) it is a form of energy.

This is not surprising. Since a body has a form of energy uniting its parts, and its parts are forms of energy united by their own forms of energy (the unifying energies of the subsystems), then you would expect that all of its behavior would also be as forms of energy.

In fact, this is the source of the scientific dogma that "whatever exists is energy (is measurable)." The things we can observe are bodies, and it would seem that if a body performed a spiritual act, it would perform an act that was beyond itself as a body—and hence it would be self-contradictory. Thus, it is assumed by scientists (particularly physicists and chemists) that all talk of spiritual activities or spiritual properties is a holdover from the unsophisticated days of the Middle Ages, where religion got mixed into science to the detriment of both.

The fallacy, of course, is that the body need not necessarily be organized with a (measurable) form of *energy*, and so could produce spiritual properties by its form of organization.

But this very dogma has led scientists *to refuse to consider* evidence that tends to refute the notion that "whatever exists is energy." The fact that living bodies tend to maintain a super-high energy level which is biologically stable but unstable from the point of view of physics and chemistry is simply not noticed by them. It argues, of course, that (since the *parts* are clearly material) the *way the parts are interacting* in a biological body is *different from and less bound by matter* than the way they interact in an inanimate body. And as you go up the scale of living bodies, this "freedom" from material limitation becomes more obvious and greater. But this is discussed in *Living Bodies*, as I mentioned.

Suffice it here that the dogma, however false, is a natural one for physicists and chemists to fall into. Biologists have less excuse.

●Note that in this book, we will be dealing only with *inanimate* bodies; that is, bodies *all* of whose acts (whether properties or acts internal to the body) are forms of energy, and which are *governed by* the quantitative aspect of the energy.

For those conversant with science, we will be dealing with bodies which follow (without "problems") the two Laws of Thermodynamics: (1) Energy is neither created nor destroyed, and (2) Any interaction always goes from a higher to a lower energy-state (The "entropy of the universe always increases.")

6.2.2. The property's relation to its body

We now come to something very mysterious. If the property is a reality, and in fact is a form of energy, then what exists? The property or the body? That is, if your color or gravitational field are *yours*, then what we must say is that what really exists is *you*, as colored and as having a certain mass.

We already saw that, with respect to the body and its parts, the body is primary and the parts secondary, because the body is basically a unit. But we now have a different version of this one-many problem; the body is one body (presumably, acts **as** one); but it **acts** in many different ways. Each of the properties are ways in which the **body** acts, not something in its own right. That is, if you strike someone with your hand, it is *you* who struck the person, not really your hand; and certainly the *act* of striking the person was not something you "ordered" done (as if the act were a kind of employee of yours), but was *you, acting*.

That is, you can't weasel out of responsibility for the act by saying, "I didn't hit him; the act of hitting did it." The act doesn't *exist except **as** your reality*. True, it is not all there is to your reality; but it is *not different* from your reality—certainly not if "reality" and "activity" mean the same thing.

Thus, your properties are your existence, in the sense that they are simply ways in which *you* exist; but no one of them and in fact (given the parts and their interaction, which are not properties) not all of them together are all there is to your existence.

Let us see if we can unpack this.

●A property has no existence of its own; it exists as the activity *of* some body.

Let me say here that only bodies have properties in the strict sense. I don't want to go into this in any detail, because this book doesn't deal with the spiritual or the evidence for saying that spiritual things exist. But it turns out that, when you analyze consciousness (which is in itself spiritual), then what you find is that the characteristic of an act which is not quantified is that it "contains itself within itself as part of itself." Consider that when you choose, you choose also to stop deliberating and make the choice; the choice chooses *to choose* (now) as well as to choose the option which it chooses; and the choice contains within it all the reasons for which it makes the choice, and chooses which of the reasons will be operative (will be the "real reasons" for the choice) and which it rejects—and so on. All the conscious "dimensions" of the choice are *not* a *system* of interrelated acts, but *ways of looking at one single act.* Thus, the spiritual is simple in reality, and so the "properties" of a spiritual act are really identical with the act itself (however distinct they might be in concept), and so are really not properties. Thus, only bodies have properties.

If this sounds mysterious and worrisome, don't let it bother you. We are not, as I said, here dealing with what is spiritual, and so this "self-interpenetration" of the spiritual need not concern us. I only mention it because some people have thought that both bodies and spirits have properties, and I am not making a mistake when I say that any property is always the act of some body.

●The property is an act of the body *as a whole*, not of the part or of the unifying energy.

Even when the body acts *through* a part that has a special function (as when we see with our eyes and brain), it is the whole body which acts, and not **just** the part.

This would have to be the case, if the body is what primarily exists, and the parts are subordinate to it. But it is also confirmed by the fact that the activity which is the property can't be performed with *only* the part, without involving other parts of the body. For instance, if you are going to see, you have to use energy to focus your eyes and pay attention to what you are looking at (if you don't pay attention, the energy coming in stays "below the threshold of perception" and is not a conscious act—or "seeing"—at all); and this means directing energy *away* from other acts you might be performing, not to mention all that goes on in relation to your consciousness of what you are seeing. Your emotions get involved, and these tend to make you want to do something; and you either act on the emotions or you restrain them—and so on. There is no such thing as a "simple act of seeing."

●Thus, the property reveals *not only* the way the body is organized (the unifying energy) *but also* the parts united by this energy.

That is, since the unifying energy is simply what the parts are doing to each other, then it follows that any property involves an *activity of the parts as they act on each other,* and so would be different if (a) the unifying energy were different, or (b) if the parts united by it were different.

So, for instance, the spectrum of hydrogen is not an act of the unifying energy of the hydrogen atom (its internal space), but of the electron and proton *as* structured this way. The internal space of the atom gives the electron certain possible "energy levels" to exist at (whether stably or unstably). If it is "lifted" to an "excited" state (an unstable one), it can only fall back to certain other states, radiating out a definite frequency of light. And the different frequencies a hydrogen atom can reradiate are the lines of the spectrum that show up when a whole bunch of them are excited.

6.2.2. The property's relation to its body

But these frequencies are different for hydrogen molecules, because there there are different parts (the two atoms) and a different configuration of internal space; meaning that certain new frequencies are permitted and others forbidden.

●Therefore, what a body *does* (its properties) reveals what it *is* (the definite parts as organized in a definite way to a definite degree).

(You may hear this occasionally in Latin: *agere sequitur esse*: "action follows existence.") And this is simply because what the body does is how the body as a whole acts.

But this means that the (single) existence (activity) of the body as a whole "splits itself up," as it were, into may different existences (activities), no one of which is the whole existence, but any one of which has no other reality than to be the existence of (or a way of existing of) the body as a whole. If you will, the activity of the body "empties itself" into a property, but remains greater than the act it is performing; it "is doing" *less than* itself in the property; and is in fact simultaneously doing the other properties, each of which is a kind of incomplete revelation of the body as a single (limited) activity.

If this sounds as if it doesn't make sense, consider that in the property the multiple unit is limiting itself, and realize that this is another mode of *finiteness*, which does not make sense by itself, and whose characteristic as such is that the finite object is in some way the opposite of itself. Here we have the unified multiplicity revealing itself in a multiplied unity (the many properties, each of which and all of which together "talk about" the body as a multiple unit).

The temptation is to put this mysterious self-contradictoriness aside and say, "It's not mysterious at all; we have a body doing many acts. What's the problem?" That's certainly the *fact*;

what the *problem* is is how *one* something can be *many* somethings while remaining one, as well as how an *existence* can be an existence while still being the existence *of* something other (in some sense) than itself.

The longer you think about it, the more unintelligible it becomes; it is not that a clear view of the body and its properties solves the problem; it simply makes the effect that much more obviously an effect.

But it is basically the same effect as finiteness itself: how something (the property) can contain the opposite of itself (the existence of the body) within it (or conversely how the body, in acting, can contain the property as a way it exists), or how something can be less than itself while remaining greater (in some sense) than its own lessness. This cannot make sense within the context of just the body; it needs a non-finite activity to be its cause. And this non-finite activity would obviously have to be simple, with no real properties.

The fact that it is the whole body that acts in the property, which therefore reveals it as a whole, is one of the reasons why I don't want to use "substance" in referring to the body. The "substance" is apt to be looked on as the unifying energy, not the body as a whole (because it is made up of "substantial form" and "matter" and seems distinct from the parts the body consists in). But "substance" in that sense (the unifying energy) is not what acts; it is the whole body which expresses itself in its properties—unifying energy **and** parts united.

Thus, the notion Locke had of the "substance" as a pincushion you stick "accidents" in is an enormous falsification of what is actually going on—and is a falsification of what was actually held by the Scholastics who knew what they were about. *Any* difference in *any* property argues to a different "substance" or a different body—even when the body remains (in our new sense) the same substance, as when you blush and stay a human being. *You* are different when you blush, and different *as a whole* from what you were when not blushing; but you do not become *inhuman* by blushing. That is, your body is still organized basically with the human form of unifying energy; but there **is** a difference in the parts **as** united by this energy (and the difference clearly would involve something about the difference in degree of unification, if the form of unification is not different).

But we will unpack all this in subsequent chapterss. Suffice it for now that the property is so intimately "related" to the body that it **is** a way of existing that the body has, and is not something "attached" to it.

6.2.3. Property and nature

The property, then, since it has no reality except that of the body it is a property of, reveals in a limited way what the body is. The property, as it were, is a partial existence of the body as a whole, and is only "distinct" from it insofar as it is not all there is to the body's existence; but it **is** the body's existence—to an extent.

But this allows us to use a term that was initiated by Aristotle and is still in use in science:

DEFINITION: The nature of a body is the body *as* revealed in its properties, or *as* "capable" of performing the properties.

That is, when you talk about a body and say "it is the nature of the body" you add "to do X and Y and Z." You are talking about the body *in relation to the properties that reveal what it is.*

And since we can't ordinarily observe from outside all the parts of a body, and since there is no way to observe from outside how and to what degree the parts are interacting (the unifying energy), then the only way we can talk about bodies is by means of their properties, and so

●We do not know the body as it is in itself; we know it as a certain *nature*.

This does not mean that our knowledge of it is *false*, but only *indirect*, by what it does to us. How else could we know it? We are not its creators, and hence cannot know it by what we are doing to cause it to exist; therefore, the only way it can come into our consciousness is for it to act on us; and this it does through its properties. Hence, we understand the nature of the body: the body as such-and-such because otherwise it could not act on us in this way.

DEFINITION: The term *nature* used absolutely (i.e. not the "nature of X") refers to the sum of all bodies that are not man-made.

That is, this is not "nature" in the sense of "the nature of X," but rather "nature" in the sense of rocks, plants, animals, and so on; the bodies that are "just there" that we didn't make. This sense of "nature" gives us "natural" as opposed to "artificial." and is the sense in which the "back to nature" movement uses the term.

6.2.4. Properties of substance

Let us now bring in the revised notion of "substance" we defined earlier, and make the following distinction:

●A property reveals either the nature of the *substance* or of the *individual body.*

6.2.4. Properties of substance

That is, bodies exhibit certain properties because (a) they have basically the same parts, (b) organized in the same way (with the same **form** of unifying energy). The properties they all have in common, then, are *properties of the substance*, because they reveal the kind of body in question.

Thus, the spectrum of hydrogen, its chemical properties, and so on, are all properties of the substance hydrogen, because *any* instance of will behave in this way.

But there are other properties (the ones traditionally called "accidents") that the body performs that are not performed by other members of the class of body in question. These are properties of the body, but not properties of the substance.

Thus, for instance, the motion of a given hydrogen atom would be a property of it as a body, because, given the energy that was acting on it, it had to be moving at the speed and in the direction in which it in fact was moving. But though this is no "accident," it is still the case that not all hydrogen atoms have this particular movement, and so it is a property of the body but not the substance.

Similarly, your basic bodily shape, your acts of seeing, walking, thinking, and so on (in general) are properties of you as a human substance; while the particular things you say, the idiosyncrasies and mannerisms you have—and every individual act you perform are properties of you as this individual (human) body.

How do you tell whether a property is a property of the substance or just of the individual body? This is what *induction,* which we discussed in Part One, does. You find cases of behavior that seem to be common to many bodies; you find some reason for believing that the behavior is due to the way the parts are organized, and you conclude that the property is a property of the substance, and any body which otherwise seems to belong to the substance and does not exhibit this property is defective.

Thus, we see so many human beings seeing that we consider blind people defective instances of human beings. And this is confirmed when we cure the blindness of the people. Obviously, the form of the unifying energy is the “power” to see; but if the part it uses to see has something wrong with it, then the *body as a whole* cannot see. But if you can fix or replace the part, then even this individual body will see, because seeing is a property that belongs to the body *because of the way it is organized*—supposing it to have the right type of part.

That is, it is of the nature of the human being as such to be able to see. A given human being cannot see because of something connected with the part that performs this function, not because of the form of the unifying energy.

It is clearly not always easy to separate out the properties of the substance from the properties of the individual; but it is just as clear that it is possible to do so. We must not let difficulties and even gross errors in the past make us despair about the power of our mind to know the natures of things (in the sense of the properties of the substance).

6.2.5. Intrinsic and reactive properties

Before we consider some of the properties that seem to be performed by inanimate bodies as such, let me make one more distinction about properties and their relation to the body.

DEFINITION: An *intrinsic property* is a property that the body exhibits by its own activity in itself, *not* as a reaction to some energy acting on it.

DEFINITION: A *reactive property* is a property that the body exhibits when *responding* to some energy acting on it.

6.2.5. Intrinsic and reactive properties

The *size, shape, and mass* (not the weight), as well as the *fields* of a body would be examples of intrinsic properties. The size and shape of the body have to do with the field-interactions of the internal parts of the body themselves. The *size* would deal with how far the farthermost parts are from each other (i.e. how *weakly* the parts are interacting through the unifying energy considered as the internal field of the body). The *shape*, of course, is the *parts **as** interacting* with the unifying energy considered as the internal field. That is, the shape of the body is how the parts are "arranged in space," the "space" in this case being the *internal* space of the body as such.

Neither of these properties depend on the body's reaction to outside energy. The *mass*, which shows up as the gravitational field of the body, is intrinsic to it, and is "there" whether the body is being acted on or not, as are any electrical or magnetic fields it might have.

Note that intrinsic properties in general *are not observed directly*. The reason, of course, is that, in order for something to be observed by us, it has to act on us in a certain way—which means to do work on our sense organs. But since, in doing work, energy is used up, then this means that the body would be losing energy as it acted on our senses, and thus would be changing.

Hence, the intrinsic properties are known *by means of* reactive properties. *Color, sound, weight, hardness, taste*, and, in a sense, *odor* are all reactive properties, or ways in which the body (i.e. the colored, heavy, etc. body itself, not us) *responds to energy acting on it*. Notice that size and shape are known *through* color and hardness, as the area that is colored or impenetrable. Mass is known through *weight*, and so on. The intrinsic properties are "primary" in the bodies (in the sense that they are "there" even when no outside energy is acting on the body), but they are *known as* accompanying reactive properties.

6.2.5. Intrinsic and reactive properties

This clears up a confusion in philosophy. The properties known **directly** by the senses (color, sound, taste, odor, and the various tactile properties) are, of course, ways in which the body *acts on* those parts of the human body which are the various sense organs we have. These, because they are *directly* perceived by the senses were called the *"primary sensibles"* in the old Scholastic philosophy. The other properties, like size and shape, were called *"common sensibles,"* because they could be perceived by more than one sense (e.g. sight and touch), and so were "common" to several senses.

Locke, following Galileo, however, hit upon something close to the distinction we made between intrinsic and reactive properties. He, however, made the mistake of thinking that the way we *perceive* the intrinsic properties was a kind of "copy" of the property itself (which is absurd, since how far away do you have to be from a foot ruler for it to appear "the size it really is"?); and for this reason he called them "primary qualities," while the reactive properties he thought of as the way *our senses reacted to* the body's act on us, and so he called them "secondary qualities," because they weren't "really in" the body, but were in *us.*

Not to get into the epistemological morass this leads us towards, let me say that (a) *neither type of property is perceived under the same form as it exists in the body,* but (b) both types of properties are *behaviors of the body, not of ourselves.*

That is, a red body that has light falling on it will be reemitting red light *whether there is an eye to see it as red or not*; a body of a certain size will have that size whether size as it is (the internal field-act) and size-as-we-see-it are the same or not; when the tree falls in the desert and strikes the ground, it makes the air and the ground vibrate, and so makes a sound whether there is an ear to hear it or not. That is, the sound is not the *hearing,* it is the vibration of the air (which is *what* is heard. In other words, the sound is the *cause;* the hearing is the *being affected* of some ear.)

How you get from the subjective reactions we have to the nature of the property as independent of **our** subjective way of perceiving it is a question of epistemology, and is discussed in my book, *Knowledge, its Acquisition and Expression;* and I will not go into the matter here, except to say that (by comparison of similar effects on our senses) we can know the similarity of the acts as their causes—and the bodies as their causers.

Now then, *color* is the reaction of a body to light that falls on it. Some of its electrons are raised to "excited" (high energy but unstable) states, and fall back to their "ground state" emitting definite frequencies of light. This reaction is the color of the body, and depends on the parts and the form of the unifying energy—and so is generally a property of the substance (though it need not be, as we can see from white, tanned, and black human beings).

The *sound* a body makes is something it does to make the air vibrate in a rhythmic (cyclic) kind of way, producing a sound wave. This, of course, ordinarily happens by way of a reaction to some energy: by striking something, or by moving through a medium, or by vibrating itself (as a guitar string does) when acted on.

The *odor* of a body is actually little particles of it broken off by interaction with the air. This is why odor appears **as** in the air (or other odor-carrying medium); if it loses none of itself, it is odorless; hence, odor is a reaction.

The *taste* of a body is the way it interacts with the taste buds as we are destroying it in the act of eating. Actually, the taste as perceived also involves odor perceived through the back air passages between the mouth and nose; but this odor is not perceived **as** odor but as part of the destructive process—or as taste.

The *hardness* of a body is the fact that its internal field resists another body's entrance into it. Hardness, of course, deals with the body's rigidity, and inability to have its shape deformed by another body's intrusion. A soft body is easily deformed. Whether the body is hard or soft, it is to some extent *impenetrable,* meaning that you can't get inside it. Bodies, do, however, allow some bodies (such as nutrinos, or even larger ones like water molecules, sometimes) to pass through them; I don't think any body is absolutely impenetrable.

Coldness and heat are the body's parts as moving and striking the other body (you) more or less strongly. If your parts are moving faster, the body is perceived as cool or cold (you lose energy to it); and if its parts are moving faster, it is perceived as warm or hot (imparting energy to you). This is why, if you put one hand in hot water and the other hand in ice water (warming one hand and cooling the other) and then feel the same body, it will appear both warm and cold. There's no mystery; it is warmer than the cold hand and colder than the warm one.

These are examples of various properties of bodies. I did not intend to give an exhaustive list of them, but just to illustrate intrinsic and reactive properties, and show how the "primary sensibles" are really reactive properties of the bodies.

Because of the confusion between "primary and common sensibles" and "primary and secondary qualities," I would offer a plea to make the distinction between intrinsic and reactive properties as closer to something that is actually "out there" in the body.

6.3. Properties of inanimate bodies

There seem to be a few things that can be said about inanimate bodies as such: that is, about the kinds of bodies that are not alive as opposed to those that live.

We are in a rather dark area here, and the statements to be made should be taken as tentative, to some extent.

●An inanimate body seems to be performing all the acts it can perform at any given moment.

That is, given a certain state of an inanimate body, there seems to be no energy "in reserve" by which it *can* act in a way that it doesn't happen to be acting in at the moment. This is easier to state by contrast with a living body. You, for instance, are perhaps sitting down now quietly; but you are aware that you could suddenly jump up and run away, without any particular influx of energy from outside.

But an inanimate body apparently cannot produce *spontaneously* a new act like that; if it is at rest, for instance, it will remain at rest.

What this amounts to is that a description of the properties of an inanimate body can be *exhaustive* in the sense that a description of the properties of a living body cannot be. If an inanimate body isn't doing something, it seems legitimate to say that it *can't* do it, given the condition it is in. But it at least seems to be the case that a living body (when asleep, for instance) is not doing all it could be doing at the moment.

Perhaps this will be clearer if we add the next characteristics:

●**An inanimate body is controlled by the *quantity* of its unifying energy (its *matter*).**

●**The *total quantity* of the properties is a reflection of the matter of the body.**

That is, given that the inanimate body is doing all that it can at the moment, then this implies that there is only so much energy to "distribute" among the properties, and all of what the body can do is used up in actually doing something.

But the fundamental quantitative limitation of the body is its *matter:* the quantity of the energy which unifies the parts. It would therefore be reasonable to say that, just as the form of the unifying energy makes the body the kind of body which it is, and gives it the sorts of properties that are properties of the substance, so that the *matter determines the energy level of the body as a whole,* and this "energy level" will be expressed somehow as the sum of the quantities of the properties.

●The natural or normal ("equilibrium") condition of an inanimate body is to have the *least* total energy compatible with that kind of body.

That is, what scientists call the "ground state" of an inanimate body is its lowest total energy, implying (if what was said above is true, the least matter of the unifying energy. That is, whenever the unifying energy "wants," as it were, to be at its lowest energy-state (have the smallest quantity or matter).

Hence, any state of higher energy is not really a *state* at all in an inanimate body, because it is *unstable,* and the body must either restructure itself to cope with this higher energy, or somehow get rid of the energy and return to its ground state (exhibiting a reactive property as it does so).

To put this another way, an inanimate body *stays the same* when it is at its lowest energy level, because it can only change by *giving off* energy, and at its lowest energy level, it has no energy to give off. Once it is in this condition, the only way you can make it do something different is to *add* energy to it, putting it in an unstable condition.

This is not the case with living bodies. They seem to have a stable condition which is **above** the lowest-energy state, and to maintain this by eating and so on. And since they exist in a kind of equilibrium at a state higher than the "ground state" I was speaking of, then they have internal energy in reserve that allows them to turn some properties on and off without being excited into a higher energy state from outside.

●**Hence, you can predict what properties an inanimate body will have by knowing the total amount of energy in the body.**

This follows from most of the above statements taken together. The inanimate body is always doing all the acts it can do, given the condition it is in; and this condition depends on the matter: the amount of the unifying energy, which shows up as the total energy of the body. Hence, if you know the energy **level** the body is to be in, you can say *what properties it will have.*

This is not absolutely true, however. We must make the following qualification:

●**It is possible that a given energy-level of the body can express itself in one of several sets of properties. If so, then which one of the sets expressed at any given moment at this energy-level will be a matter of chance.**

What I am saying here is something that seems to be true from quantum mechanics. If you add a certain amount of energy to a hydrogen molecule, for instance, this energy can be absorbed by the body in one of three or four ways: that is, one or both of the electrons can be "knocked out of orbit" to a higher-energy shell, which puts a strain on the unifying energy, making the molecule unstable until the electron or electrons fall back to the ground state, radiating out the wave length of light that corresponds to the energy they absorbed.

But since there are three or four possible "excited states" (each with its own characteristic spectral line or lines as the light gets radiated out) the molecule can be in with this same total energy, then *you cannot predict which state* a given molecule will be in when you add the energy to it.

Nevertheless, since there are only three or four possible states that can exist at this energy level, *you can predict statistically* what will happen to a large amount of hydrogen molecules when they are raised to this energy level. That is, you could predict, say, that twenty-five per cent of them will be in state 1, twenty-five per cent in state 2, and so on.

Philosophers differ in speculating upon whether something in the individual molecule *forces* the molecule to be in one and only one of these "permitted" states, or whether all that is forced is that the molecule has to be in *one* of the states, but could be indifferently in any one. I don't think that the notion of "cause" I developed earlier would allow you to settle this issue. The cause of the molecule's being in State 2 is the energy added to the molecule (i.e. this is the explanation for the higher-energy state); the cause of its being in state 2 *rather than* state 3 may not exist, simply because this may not be an effect, but a simple fact. That is, there is no *reason why* it should be in state 2 rather than State 3, except for the fact that it can't be in both of them. That is, if something is what it is, this is not of itself an effect that needs an explanation; the fact that something *could* be different does not mean that there has to be a reason why it isn't different. Why are you an American rather than a Nigerian? Once you've said that your parents were Americans, you've given all the answer that can be given; if they had been Nigerians, you would have been Nigerian; but they just weren't, that's all—so ultimately, you just are American. To pursue this "well, but *why?"* further is an exercise for five-year-olds who do not understand the difference between facts and effects.

●Presumably, an inanimate body at its lowest energy-level is

performing all its intrinsic properties, and none of its reactive ones.

Obviously, if reactive properties mean that the body is reacting to energy impinging on it, then this means that the energy is raising it to an excited state, and the property is its means of coping with this excited state.

But the intrinsic properties are "there" whether the body is being acted on or not; and hence, they would be the only properties it would have when in its "ground state." So in inanimate bodies, at least, the intrinsic properties are the properties of the body in its ground state.

Clearly, since all bodies are in fields and hence are acted on by other bodies, then no body is ever absolutely in its "ground state"; in order to be, it would not be able to be in any position with respect to any other body (since position is its *reaction* to the action of the other body's field).

Still, the position of a body does not ordinarily seem to make a great deal of difference to its total energy, and so there can be numerous approximations to the "ground state" which are so near it as to be practically indistinguishable from it.

In this discussion of the properties of inanimate bodies, we have already had to introduce concepts that really belong to what happens to a body when it changes; and so it is now time to turn on the motor, so to speak, and consider philosophical dynamics.

PART THREE

PHILOSOPHICAL DYNAMICS

CHAPTER 7

CHANGE

7.1. Change vs. replacement

Change is one of the most obvious facts we are confronted with; and it is one of the facts that science finds most interesting. And the reason why it is interesting to science is that change is the most obvious case of an effect, because *the same thing becomes different while remaining the same*.

Recognition of both sameness and difference are necessary for us to consider that something has changed; and this apparently contradictory situation always confronts us as needing an explanation.

First of all, it is obvious that there has to be a *difference* of some sort in order to say that a change has taken place. If the body (or anything at all) remains the same, this is another way of saying that it has not changed.

But at the same time, there cannot be *total* difference, or we would not be able to say that "something" changed. You might think that if you burned the book you are reading, then the ashes resulting are not "the same" as the book; but there has to be *some* sameness between them, because what happened was not that someone took away the book and put ashes where it was. *These* ashes *were* the book.

Actually, this substitution is what the magician does when he asks you to believe that the silk hankerchief he put into the hat "turned into" the rabbit he pulls out. We didn't see the substitution take place, but we know that silk handkerchiefs do not become rabbits, and so we know that the one he put in there didn't change into one, and there was a replacement of the handkerchief by the rabbit. Of course, there was *some* change (of place) in both the handkerchief and the rabbit; but the point here is that in order to say that A changed into B, you have to be able to say that *something* about B is *the same as* something about A.

●Hence, annihilation of something and creation of something else is not a change of the first into the second.

That is, if (supposing it to be possible) this book were suddenly totally to vanish and then a pile of ashes suddenly to come into absolute existence, this would be the same as the magician's trick with the rabbit. You might *think* that the book turned into ashes, but it didn't.

●Annihilation or absolute creation cannot be considered changes, strictly speaking.

The reason for this is that if something simply goes out of existence, you can't, in a sense, talk about what happened to it (because there isn't any "it" any more—in any sense—to talk about); it didn't turn into anything; it just stopped. Similarly, if something absolutely comes into being, it didn't "come from" anything at all; it just began. Nothing changed into it—which does not mean that "nothingness" changed into it, but that "it is false to say that something changed into it."

This is perhaps not terribly signficant except to clarify what we are talking about when we refer to a change: there must be (1) some difference, with (2) some continuity or sameness.

7.1.1. Change and bodies

Given that a change needs something by which what changes can be identified as the same and also something by which it can be identified as different, then we can conclude the following:

●Only *bodies* (or systems of bodies) can change.

There are three things we need to investigate to reach this conclusion: God (the Infinite Activity), spirits (those acts not limited quanttatively), and bodies.

First, the only possible "change" God could undergo by which He could be any different would be to "become" something finite. If this were to happen, He would not change, but He and absolutely everything else would go out of existence; because anything finite is a contradiction unless it is *being* caused to exist as finite by the Infinite Activity. So, even if this were possible, it would not be a change.[2]

Second, for a spirit to change, it would be necessary either for it to become a different *kind* of spirit, or for it to have a different property (supposing this to make sense). In the first instance, there

[2]For those who believe that God "became" a man in Jesus, the answer is that a spirit (i.e. something without quantity) "does itself" many times in one single act, and one (the second one) of God's "multiplications" of himself, He "emptied himself" by performing only human activities, even though He *was* still infinite, just as I might refuse to perform some of my properties. Thus, He remained divine, and did not really *become* human; he *restricted himself* to human activity (and therefore had a true human *nature*, even though He is a divine person. There's no real contradiction here.

would be nothing in common between the spirit that existed "before" and the one that exists "after" the "change, because there is only (a) existence and (b) the form of existence. But the *existence* can't be a "common element" enabling us to identify the second existence as "the same" as the first, because *any* two forms of existence can be called forms of existence. That is, existence is not a "common element" all activities **share,** as if it were a property; the form of existence *simply means* that the activities are of different kinds (it is not a "something" in addition to the existence). Thus, if the first spirit were annihilated and the second absolutely created, the second would still be a form of existence—and you couldn't say the first turned into the second. Hence, there is nothing in the spirit which would identify it in any sense as "the same" as the spirit before the change. So spirits can't become different kinds of spirits.

In the second instance, if the spirit acquires a new property (or loses an old one, the argument being the same), then even if spirits had real properties, the acquisition of a new property *implies* a *difference in the spirit as a whole*. But a "spirit as a whole" is precisely just a form of activity; and so any difference would mean a different form of activity—which is what we saw in the preceding paragraph could not happen. Hence, a spirit cannot change any of its properties.

Actually, spirits don't *have* properties in the true sense of the term, because the spiritual act, as I mentioned earlier, contains itself within itself; and so any "properties" would be one and the same act as the spirit. That is, any "ideas in the spirit's mind" would be identical with the whole spirit in reality, because each "idea" would contain within it (as conscious) every other "idea" the spirit had. But this is a complication that need not concern us except that it confirms that the spirit cannot be different *in any way* without being a different spirit; but in that case, it cannot change, because there is nothing to establish a continuity between "before" and "after."

7.1.1. Change and bodies

Notice that you can't even *replace* a spirit with another one, since to be in a position means to be acted on *to a certain degree* by the fields of objects; but the spirit, not having a degree, can't be acted on to any degree—and hence is not in any position; and therefore, if he is annihilated and another spirit created, the second does not "take his place."

It therefore seems that you need the level of limitation of *quantity* in order for something to be able to change. If something becomes a different *form* of something, then the quantity before and after remains constant (which sounds suspiciousy like conservation of energy, doesn't it?); or if something becomes greater or less, then it is the same form of something that becomes greater or less.

Hence, it seems that change is a characteristic of energy or systems involving energy.

Note that we have *not* established that **if** something is a body it *can* change. All that we have been able to show so far is that if it is *not* a body, it *can't* change. It is at least conceivable that there could be unchangeable bodies.

7.2. Kinds of change Bodies are what change, then. Even when systems of bodies change, the bodies in the system must change *somehow* in order for the system to be any different. That is, the motions of the planets in the solar system seems at first glance to be something that is only going on between the planets, and in no sense within them; but this is only a superficial view. Insofar as the distances between planets vary, then they attract each other with different force, and hence the response to that force on the part of the planets will be different. Or, for instance, the drag of the moon on the rotation of the earth can be seen in the tides of the ocean. Hence, we can say that real changes in systems of bodies will imply changes in the bodies in the system; and so we need to look at how bodies can change.

There are two different sorts of changes bodies can undergo:

DEFINITION: A *substantial* change occurs when the body becomes a different *substance* (i.e. *kind* of body).

DEFINITION: An *accidental* change occurs when the body becomes different, but remains the *same substance* (i.e. kind of body).

Note that this does not mean that a substantial change is a change *of* the "substance" (the unifying energy), and an accidental change is a change only in one or more "accidents" (properties). This was the oversimplification that some teachers taught in the late Middle Ages, and which was easily refuted by such philosophers as John Locke and David Hume.

No, an accidental change means that the *body as a whole is different*, but not that it is a different *kind* of body. Thus, when you blush, the new property you acquire (redness) means that you have been embarrassed, certain blood vessels have contracted and others (the ones on your cheeks) have dilated; your cheeks become hotter, your heart beats differently, etc., etc. The change takes place all through you, and you are different as a whole—which would have to be the case, since the property reveals the body as a whole.

Still, when you blush, you do not cease to be a human being. Thus, your substance, your kind of body, is still the same, though the body is different.

On the other hand, when a dog, say, dies, the corpse has many of the same properties (at least for a while) that the dog had; but the corpse of a dog is not the same substance as a dog; it is a different kind of body altogether, because the parts are no longer organized in a "doggy" kind of way, but behave more or less independently of one another. In fact, the corpse is now a system of various bodies, really, and not a single body any more; though it was a single body when it was a dog. So the death of a dog is a substantial change.

● **Note that certain interactions can be substantial changes from one point of view and accidental changes from another.**

When you eat an egg, for instance, the *egg* ceases to be organized as an egg (the parts no longer interact in an "eggy" way), and the parts become assimilated into your body, and hence become parts of your body. The egg has undergone a substantial change, and has *become you*. So even though it isn't the case that "you are what you eat," it is true that what you eat is you (afterwards).

On the other hand, though you have gained some new parts and have increased your total energy-**level**, you are still a human being—the same substance you were before. So from your point of view, the change was accidental.

There is no contradiction here. If you ask what happened to the egg, the change was substantial; if you ask what happened to you, the change was accidental. There is no egg any more; there is just you—different from what you were, but not a different kind of thing.

7.3. Internal causes of change

It was sometimes taught that, just as in accidental change what remained constant was the "substance," so in substantial change what remained constant was the matter, and the "substantial" form was different. But in fact, with what we know now, this is a considerable oversimplification.

We can, however, make a reasonable description of what it is inside the body that allows for it to change—and in a given direction—if we take account of some of the properties of inanimate bodies we mentioned in the last chapter.

Inanimate bodies are controlled, as it were, by their matter, or by the *amount* of the energy unifying the body. This implies that *a given form of unifying energy* (at least in inanimate bodies) *can only exist with a certain matter.*

Let us define a couple of terms which will be useful:

DEFINITION: *Equilibrium* is the condition in which the form of the unifying energy of a body has the matter (i.e. quantity) appropriate to it.

DEFINITION: *Instability* is the condition in which the form of the unifying energy has a matter that is incompatible with it.

That is, a body can only have a certain "shape" or configuration of its internal space (form of unifying energy) at a certain energy-**level** (matter). And this energy-level, as we saw, is the *minimum* amount of energy for this particular configuration of space.

If energy is added to the body and absorbed by it, then this distorts the internal configuration of the space, making it impossible for the body to exist as this kind of body at this energy-level.

That is, instability is an *internal contradiction* between the form of the unifying energy (which can only exist at a certain energy-level) and the matter (an energy-level different from the equilibrium level). But contradictions can't exist. Hence, the body *cannot stay* in the condition of instability.

[Note that instability is also this internal contradiction in living bodies also; but since they have a "biological equilibrium " *above* the ground-state, then they can be unstable either above or below this biological equilibrium-level. Inanimate bodies are unstable *only* above their equilibrium, since equilibrium is the lowest energy-state.]

I think we have to add that this distortion of the internal field creates a strain of some sort on the unifying energy and does not absolutely destroy it immediately. So that, even though the unstable condition implies an internal contradiction, it is not an absolute impossibility, and the body *can* be in the unstable condition, if only instantaneously.

The point, however, is that *if a body is in an unstable condition, it immediately does something to get back into equilibrium.* It changes, in other words.

Now there are two possible things the body can do: (a) it can *restructure* its internal field (the way the parts interact) so as to cope with this new energy-level, or (b) it can *get rid* of the excess energy and return to its ground-state.

If the body restructures itself, then it becomes a different kind of body (a different substance), and so we have a substantial change.

If the body returns to its ground-state, then the energy it gives off *appears as a reactive property,* and we have an accidental change.

●Since inanimate bodies are controlled by their matter, then what the body is going to do and what its future equilibrium will be will depend on the amount of the excess energy introduced into it.

That is, inanimate bodies' changes are predictable if you know the *amount* of excess energy that makes up the instability.

For instance, if you take a test tube of mercuric oxide and hold it over a bunsen burner, the glass in the tube becomes hot, and the increased heat adds energy to the molecules of mercuric oxide (i.e. the faster-moving molecules of the glass hit the molecules of the mercuric oxide harder).

For a while, the molecules of mercuric oxide cope with this extra energy added to them (distorting their internal fields) by moving faster and hitting other molecules, transferring the excess energy to them (and making the whole system hotter).

But when a critical heat is reached, the molecule cannot by the elasticity of the forces inside it recover from the distortion, and it breaks apart, forming now atoms of mercury and oxygen (which, themselves unstable, form oxygen molecules).

So the first change as you heat the mercuric oxide is the accidental one which shows up as the reactive property of heat—and as you add more and more energy, the heat increases. But when the critical temperature is reached, the substantial change of becoming mercury and oxygen occurs. And you can tell when this restructuring of the internal space of the molecule will occur—if not by your theory of the "binding energy" (the unifying energy) of the molecule, then by observation at the temperature at which this happens. You will find that it always happens at just this temperature.

7.3.1. Conservation of matter

This theory of what happens in a change ought to be able to make some sense out of what physicists and chemists have observed in changes.

First, let us consider the law of "conservation of matter," which is now more generally formulated as the "conservation of mass-energy" (since in physics "matter" is not a technical term, and is almost but not quite equated with "mass," which ever since Einstein we know is not conserved.

What this law is actually saying is

●In any change, the total *quantity* of the energies involved remains constant, even if the forms of the energies differ.

This really is the "conservation of matter" in our sense of the term, if the matter (the quantity of *unifying* energy) is what controls what is going on in inanimate bodies.

Consider: if energy is introduced into a body, then the matter of the unifying energy is greater (the configuration of internal field is distorted because there is more energy in it than it can support). The body must then cope with this unstable condition.

If it changes accidentally, it does so by giving off the excess energy which it acquired, and falling back to its ground-state equilibrium. In this case, the amount of energy it gets rid of is the same as that which it absorbed when it became unstable. A new property is "acquired," but the total energy (original equilibrium + absorbed - emitted) remains the same.

If it changes substantially, it restructures itself in such a way as to be able to exist at this new energy level. In this case, the new substance(s) will obviously reflect the old equilibrium + the energy absorbed; and so the total energy will be the same.

Now of course, this body which has absorbed energy has to have got it from somewhere; and it would have got it either from "free energy" (if there really is such a thing), in which case, the amount it absorbed means that there is that much less "free energy" floating around; or it got it from some other body which is unstable (such as the sun, for instance) and emitting energy by falling back to its ground state. If you take this energy into account (the energy given up by the causer) you will find that this is the energy absorbed by the affected object—and so the two are clearly equal, since they are the same energy.

Hence, no energy is *lost* in an absolute sense or *gained*. The matter (quantity of internal energy which indicates quantity of total energy) of the bodies in the system is conserved.

So this theory of change makes sense out of the first law of thermodynamics: that "energy is neither created nor destroyed"—and while it is at it, it shows the relation between this law and the conservation of matter, and why the conservation of "matter" in the naive sense of the old physics has to be reinterpreted as the conservation of the *quantity of total energy.*

7.3.2. Entropy

If changes go from instability to some equilibrium, and if instability is (in inanimate bodies) an *excess* of internal energy, then this theory also explains the second law of thermodynamics: that the entropy of the universe always increases.

Let us look at what this law is saying. Basically, it says that whenever work is done (whenever energy is transferred from the causer to some affected object), the transfer is never a hundred per cent efficient; some energy is always wasted (and can be considered as heat given off—which is why this is a law of thermodynamics, the study of heat). This is one way of looking at the law.

Note that this does *not* mean that the energy wasted out of the bound state of the body or system *goes out of existence.* That would contradict the first law. No, what it says is that the energy is given off **out** of the system as "free energy."

In this sense, "entropy" is the tendency of energy to *leave* a "bound system" (a body or system of bodies) and be dissipated into the universe. Entropy is positive when the energy escapes the body and doesn't become bound in other bodies; it is negative if it is absorbed by a body from the surroundings.

Now then, if instability is an **excess** of energy *inside* a body, it follows that the *equilibrium implied by this excess* will be some *lower* energy-level of the body in question; and so some energy will be *given off* by that body as it goes from instability to equilibrium.

This will be true even in substantial changes, presumably, at least in inanimate bodies. The restructuring of the internal space of the unstable body or bodies will be such that the restructured space is "more efficient" than the unstable structure, and so the unstable body or bodies will "drop" into this new configuration, giving off energy.

7.3.2. Entropy

Thus, a mixture of hydrogen and oxygen is in equilibrium because the internal energies of the hydrogen and oxygen molecules keep each other far enough apart so that they don't interfere with each other's space. But once some additional energy is introduced, forcing the molecules into each others' "territory," so to speak, a more efficient form of internal space becomes possible, and the molecules fuse together into water, giving off energy + an oxygen atom, which, moving faster, causes further disruption of the molecules near it, forcing others into this same new configuration; and the result is an explosion, with the whole system giving off a good deal of energy and becoming water (and possibly some excess oxygen, depending on the proportions of the original mixture).

Another way in which the second law of thermodynamics and entropy can be looked at is that the natural tendency of systems is toward randomness, not system. That is, energy tends to "unbind" itself rather than "bind" itself into bodies.

Obviously, there are cases where simpler systems (such as hydrogen and oxygen) combine naturally into more complex ones, *when the total energy* of the more complex system (or body) is *less* than the total energy of the (unstable) parts. But in this case, energy is given off, and so there is less energy left to bind things together.

And since this energy given off ultimately takes the form of heat, which is simply the random motion of parts of a body or parts of a system, then there is a kind of net increase in randomness even in these cases.

If, however, you are dealing with loosely knit systems, then this law says that if there is a non-random distribution of the elements to begin with, it will become random, and a random distribution will not systematize itself.

That is, if you drop a drop of ink into water, the ink will spread through the water until it is evenly distributed throughout. Inky water will not have the ink collect into a single area.

7.3.2. Entropy

The reason for this seems to be that it takes more energy to keep the ink molecules all in the same place than for them to be batted any which way by whatever they come in contact with; and so water moecules will begin to invade the ink, and knock the ink farther and farther into the water. In order to collect the ink all into one place, you would have to work to keep the water molecules out of that area against their random tendency to go just anywhere. But this would take extra energy.

Hence, this is just a statistical way of stating that *the tendency of any change is from a higher-energy to a lower-energy condition of the system changing.*

And this in turn is another way of saying that in inanimate bodies, equilibrium is the lowest energy-state compatible with the configuration of the body in question, and instability is always a state of too much total energy—which is what our theory says.

[Note that funny things happen in thermodynamics when you consider living bodies (which spontaneously increase their total energy up till the point of "biological equilibrium" and then stay stable—in a sense—by losing and absorbing energy from then on). These are "open systems" in thermodynamic terms, where you have to consider the environment also in order to "close" the system and get the two laws above to work. That is, in order for these two laws of thermodynamics to be applicable to living bodies, you have to widen your perspective until the living bodies become *parts* of a basically *non-living system* of bodies. Then this whole system behaves according to the laws of physics. But the living parts of it don't really do so. Physicists tend to ignore this, because it implies that living systems are **not** simply fancy cases of inanimate systems, obeying the same laws—and so they invent terms like "open systems" to gloss over the contradiction between what is observed and what their laws (which apply only to inanimate bodies) say should be happening. Once you've put a name to something it looks as if you've nailed it down and explained it. You haven't.]

7.4. External causes of change

Aristotle called the "internal causes of change" matter and form, and in a sense the theory advanced here agrees with him. What Aristotle called "being in potency" I have called "being unstable," and only something that has a unifying energy (and so is a body or system of bodies) can be unstable, because instability is the discrepancy between the form of the unifying energy (or internal space of the body) and its matter (or strength of this internal field).

Aristotle considered matter to be "potency" to act (remember, he also thought of it as a kind of "stuff" which acted, not as limitation of the form of activity); but there is a difference between "potency" to be (any) form of activity and being *in* potency (to being some definite form of activity). He spoke of being "in potency" as a kind of "privation" or "lack" of some definite act. So, for instance, for Aristote, matter could be an egg or a human being, say; but the matter of the egg would be "in potency" to being human when the egg was being eaten; it now somehow "had to be" the matter of a human being and nothing else.

7.4.1. Purpose

Aristotle then considered the thing which was "in potency" to have an "end" or "purpose" outside itself; and it changed and got the "end inside itself" and existed in a rational way again, acting as it was capable of acting, and not being deprived of any form of activity.

Hence, Aristotle considered the "purpose" (which didn't exist yet or was "outside" the "being in potency") to be one of the *external* causes of change. Every change would have a purpose (the form which was "lacking").

Thus, Aristotelian science was couched in terms of "purposes"; the form toward which a change headed was the purpose of the change. This has been downplayed in contemporary science, because the "purposiveness" got interpreted by the Christian commentators on Aristotle as what God wanted for the inanimate world—because you can only have a purpose when you know where you want to go, and obviously inanimate things can't know where they're headed—so God has to push them in the direction **he** wants them to go.

This was not at all what Aristotle had in mind; he was simply trying to account for the *predictability* of changes when conditions are basically the same. For Aristotle, this "purpose" which was just the (blind, mechanical) acquisition of the form that was "lacking" somehow was the primary notion of purpose, and human purpose (where you know what you want) is a notion derived from it (because you get headed somewhere).

In any case, I think our theory can show that Aristotle's notion of "purposiveness" is not foreign to modern science, but as a matter of fact is very heavily present in it; it explains the predictability of changes.

DEFINITION: The *purpose* in any change is the *equilibrium* implied in the instability.

That is, bodies change because they are unstable. Each instability, however, "heads itself" toward a predictable equilibrium, which is either the ground state (giving off the reactive property, in an accidental change) or a new structure (of a definite sort, in a substantial change). In inanimate bodies, we saw, this *future equilibrium* is predictable by knowing (a) the original equilibrium and (b) the *amount* of energy added to the body.

Now modern science is apt to ignore this, and say that the future state is predictable by knowing the *energy acting on the body.* That is, it's "what you do to it" that determines the future state, not some "purposiveness in the body itself."

But this is clearly contrary to fact.

For instance, if you take a mixture of hydrogen and oxygen, and you drop a lighted match (chemical energy) into it, you will get the explosion and water. If you pass a spark through it (electrical energy) you will get—the same explosion and water. If you compress it suddenly (mechanical energy) you will get the selfsame explosion and water; if you heat it up enough (heat energy) you will again get the explosion and water.

The point is, of course, that *it makes no difference what the energy introduced into the body or system is,* so long as it is the right amount.

Hence, it is *the fact that the body is unstable to a particular degree* which makes the results predictable, not what the energy was that got into it. That is, it is the internal distortion of the body which makes the new equilibrium predictable, not the form of the energy which distorted it; the distortion only depends on the amount of energy absorbed.

Hence, Aristotle's notion of "purpose" which was based on "being in potency" is actually a *more accurate* description of what is going on in scientifically predictable changes than the current scientific thinking which tends to shun "purposiveness." But modern science is right at least to this extent; "purposiveness" as we have defined it has ***nothing to do with somebody's*** **motive** ***for doing anything.*** It simply means that a given instability implies a given equilibrium, and if you know enough about the instability, you can predict the equilibrium.

With that said, we can resurrect the Aristotelian concept of purpose as scientifically useful; and we can add the following statements:

●**Only *change* have purposes. Equilibrium has no purpose.**

7.4.1. Purpose

This is obvious. Purpose is a *future* state, with its "seeds" somehow in the present; it is something that does not yet exist as such. But equilibrium *exists; indeed, it* is *existence* in its most meaningful sense.

Something that "has a purpose" does not have (as Aristotle rightly noted) its full intelligibility in itself, but in some future condition of itself; it is not yet what it will be. But what is in equilibrium is completely what it is.

True, what is in equilibrium is *finite,* and hence is not completely self-explanatory; and so (as we briefly saw) needs God to account for its finiteness. But this is not the "incompleteness" we are talking about in instability, where the body is in a self-contradictory condition as it exists, and must exist in a different way or to a different degree.

A body in equilibrium depends on God, but is *not headed toward God*. This was the misinterpretation of "purpose" introduced by the Christians that has resulted in the whole concept's being thrown out by science. The body in equilibrium is *stable,* and intelligible as what it is (though finite); the body that is unstable is only intelligible through a future equilibrium.

Thus, not everything has a purpose; only changes (or, if you prefer, instabilities) do.

Secondly,

●**All changes have a definite purpose.**

This would have to be the case. If the body is unstable, it cannot exist in this self-contradictory condition, and so must lose energy or reconfigure itself. Each of these would be a definite purpose.

Well, but couldn't it just keep changing? No, because (absent any new introduction of energy creating a new instability), there is only a finite amount of energy in the body, and if changing is from higher to lower energy, then it has to give off energy—and eventually it is going to run out of energy to get rid of.

●Those apparent "changes" that are cyclic, where no energy is lost out of the system, are not changes but equilibrium.

Let me illustrate by the "perfect pendulum." If you start a pendulum going, and no energy leaves the system (by air resistance or friction), then the bob swings to the other side of its bottommost position *exactly as far* as it was on the first side; exactly all the kinetic energy is reabsorbed as potential energy, and it starts to swing back until it reaches its original position, where once again all the kinetic energy is potential energy, and this goes on forever. *This would not be a change, but an internal activity of the system.* The system is not **unstable,** as can be seen from the fact that it really never gets any different; it is simply active, not changing.

Now of course, no real pendulum is that way, because in fact when you pull the bob to one side (raising it up because of the rigidity of the arm), you have added energy to it. It then swings back, and (because of friction at the fulcrum and air resistance and so forth) it doesn't quite make it to the height it was when you let it go, and when it returns, it's a little lower still; and so on for each swing, until all the excess energy is removed, and it comes to rest at the bottom of the path of the swing. This *loss* of energy (what the physicists call the "envelope" of the curve) was the *real change;* the swinging was the **way** the pendulum lost energy.

And by the second law of thermodynamics, you can never *add* energy to a real pendulum (or any other system) raising it above its ground state without having it find a way to dissipate this excess energy.

Hence, *any* change will be headed toward a definite equilibrium—which it may not actually arrive at, if new energy is introduced before it gets there, creating a new instability—as when you wind a clock, making it give the pendulum a little push at every swing (restoring the excess energy and thus the instability).

In fact, the whole universe is headed toward a definite equilibrium: the "heat death" the astronomers talk about in the vastly far future, where all the stars will have burned out and there will be nothing but heat, with the temperature of space being raised some four or five degrees absolute.

7.4.2. Efficient cause

Aristotle was right, then, in saying that you have to take into account the predictable future state (the purpose) if you want to make sense out of change. So we have three, so far, of Aristotle's "four causes" (form, matter, and purpose). And, like Aristotle, we can say that the purpose is a form, in a sense; that is, the predictable future state will involve some property (his "accidental form") or some new internal structure or form of unifying energy (his "substantial form").

The last of the "four causes" is the one everyone admits, and which has recently become synonymous with "cause." It is traditionally called the "efficient cause," and I see no need to change terminology here.

DEFINITION: The *efficient cause* is the external energy which is introduced into a body, making it unstable.

This is the second of Aristotle's "external causes," and is obviously outside the body, since the energy level of the body is raised by it. Clearly, the body cannot give itself more energy than it has; and so in inanimate bodies, instability always implies an efficient cause.

[This is not necessarily so in living bodies, because their equilibrium is not their lowest energy-state; hence, if their energy drops below their "biological equilibrium" by natural processes, then this creates an instability without anything's being done to them from outside. Similarly, in those living bodies that have consciousness (which is not energy), the internal energy can be shuffled around by—for example—a choice, creating an instability in the body which was not there before the choice was made, and was not brought into being by any energy from outside. The choice itself can be made without any introduction of outside energy, because the choice is a spiritual act, without quantity. But this gets us into complications that are not part of this discussion. I mention in here, however, to show that, though inanimate bodies cannot act spontaneously (i.e. without being acted *on* by outside energy), living bodies and especially human bodies can act spontaneously.]

Note that the *energy itself* which is introduced into the body is the efficient *cause;* the *body* which *gave off* that energy is not the efficient cause, but the efficient *causer*. It has been a failure to make this distinction that has been the (logical) cause of a good deal of trouble in philosophy, and even sometimes in science.

Thus, if one billiard ball strikes another and makes it move, the first ball is the *causer, not the cause* of the movement. The *kinetic energy* of the first ball is the *cause* of the motion of the second one; because this is what was added to the second one (and subtracted from the first one), creating the instability in the second one which gave it the purpose of the property of movement and eventual rest somewhere else.

We say that the first ball "caused" the second one to move; and this is true; but it was the energy it imparted to the second one which was the cause of the movement; the first ball was the caus*er,* and has properties that had nothing to do with the movement.

Note that if the energy which is the efficient cause is energy *given off by* an unstable inanimate body which itself is seeking equilibrium, then the excess energy (the instability) of the *causer* needs an efficient cause. And since the energy of *both* the causer and the affected object is *greater* than before, *the regress cannot be infinite*. That is, if A's energy increases because B's energy is above equilibrium, then B got its increase from C, and so on; but you can't go on forever in this, because the combination A + B has more energy than equilibrium; and so does A + B + C, and A + B + C + D...; the *whole system* is in an unstable condition, with energy *in excess* of its equilibrium.

Hence, for any series of instabilities whose cause is energy given off by an unstable inanimate body, there must be a "first efficient cause" which is **not** an unstable inanimate body.

St. Thomas Aquinas used this as his "second way" for proving the existence of God; but unfortunately, it doesn't work. There are two possible explanations which don't need God. First, any one of these series can be stopped by an act of a living body (which can change spontaneously). Second, the whole universe might be like the "perfect pendulum" I mentioned above, and be in a state of "pulsating equilibrium," trading off energy between parts of itself and alternately expanding and contracting. Thus, the "big bang," the "first instability" which gives off the energy that starts the whole thing going, might be in fact the result of the *collapse* of the previous phase of the universe into the "fireball" which exploded.

If, of course, this unstable "fireball" can be shown *not* to be the result of a collapse of space (and this depends on the total amount of energy in space), then obviously the *beginning* of the universe as we know it is not self-explanatory; because an instability is a self-contradiction; and an *unstable inanimate body* (as the "fireball" would have to have been) would have to have an *excess* of energy which it couldn't have given itself. But if this is the whole of space, then there is no *body* it could have got this excess from.

It doesn't follow that this unstable "fireball" had then to have been caused by *God,* however. All that would be needed would be something that could raise the energy level of some kind of preexisting material into this instability. Granted, what this could be boggles the mind; but it wouldn't necessarily have to be (based on this effect alone) something infinite.

This, then, is what change looks like from the point of view of the body which changes. What about the **act** of change? This is the subject of the next chapter.

CHAPTER 8

PROCESS

8.1. Change as a property

When we think of something as "becoming" different, we ordinarily do not think of the change as instantaneous: you have X one minute, and then suddenly, with no "between," you have Y. Even in substantial changes, there seems to be a gradualness to them so that we can say at some point that the body is not what it used to be, and is not yet what it will be. In the process called "dying," for instance, obviously the body is either alive or dead; but still, when a body is dying, it is *going toward* being dead from being what you might call "fully alive." It is this chang**ing** that we are now going to look at.

In one sense, I suppose, a substantial change has to be instantaneous or immediate: the body is organized either with one form of organization or with some other one; as far as forms are concerned, then *as such* they don't admit of degrees; their degrees precisely *are* quantity.

Still, it would seem reasonable to say that any substantial change in a body would always be preceded by or accompanied by an accidental change, where the unifying energy would attempt to cope, as it were, with the efficient cause (the energy disturbing it) until it finally had to assume a different form of internal space of the body; so that it would seem that any change would show up as some *property* that could be observed.

This may be true in the macroscopic order (i.e. in bodies big enough to be seen with the naked eye); but when you get down to the level of the atom or molecule, things are not so clear. Even accidental changes there are not obviously gradual, because there apparently is no meaning to "between" the different conditions.

For instance, when light falls on a molecule, it is raised to an excited state. Now between the ground state and this excited state, there is a finite energy difference, *but according to quantum mechanics, the intermediate degrees have no real meaning.* That is, between zero and one, mathematically speaking, there is one-half and two-thirds and so on; but this kind of continuous set of degrees apparently does not describe the real differences in energy. There is just zero or one. Hence, there is no transition in which the energy passes *through* the one-half point to get from zero to one; and similarly, when it falls back to its ground state, it goes *immediately* to zero without "passing GO"; one-half is not a concept that refers to anything in this case.

Hence, it would seem that such transitions are of the either/or variety, and in the microscopic order, there is no "act of passing between" A and B.

Nevertheless, there are some cases when the body does have an active transition, and we can consider these.

DEFINITION: *Process* is a change *as* a property of some body.

That is, process is *the act of changing,* or *what the body is doing to get back into equilibrium.* Aristotle defined process (what is usually translated as "movement," but his examples show that he was talking about *any* gradual change) as "the activity of what is in potency insofar as it is in potency." If you remember, his being "in potency" means what we called being unstable; and hence, process is the activity something performs *because* it is in an unstable condition—or it is the activity by which it gets out of instability into equilibrium again.

Process illustrates, I think, most clearly of all properties, that it is not an "accident," in the sense of something "added to" the body, but is what *the whole body is doing as a whole*. The body is struggling to adapt somehow to this (in the case of inanimate bodies) excess energy; and what it is doing is observable. This is the property called the "process." **Any** property is like this; but process shows it best.

Let me use Aristotle's example of the process called "construction" to illustrate what a process is. Clearly, construction of a building is some kind of activity. Is it, Aristotle asks, the activity of the bricks as bricks? No, because when they are acting as bricks, you just have a bunch of bricks. Is it the activity of the bricks as a building? No, because when the bricks are acting as (that system called) a building, the process of construction has stopped. Is construction the bricks acting as partly a building? No, because you could stop construction when the building is half finished, and the bricks would continue acting as part of a building. What construction **is** is what the bricks *are doing* (i.e. in this case what is being done to them, but this is an activity on their part also) *because they are not yet a building and will be one*. That is, it is the act they are performing precisely as in the unstable condition whose purpose is the building. It is what they are doing to *get to* the purpose from where they are.

Note that reactive properties are either processes or, like color, the macroscopic way in which the quantum-mechanical transitions I described above occur. That is, color is the way the molecule reacts to light hitting it, whether that molecule is an element of a more or less tightly knit system (such as the paint on the wall) or a part of a true body (such as you). Each molecule reacts to the light hitting it, gets excited, and falls back to its ground state radiating out the wave length it absorbed. As long as light is striking the body, millions and millions of molecules are going to be doing this, and as each returns to equilibrium, others will be getting excited; and so the large body seems to be "reflecting" a uniform color (which is actually a mixture of the various wave lengths emitted by the different molecules). Of course, as soon as you turn out the light, this re-radiation stops, and the body as a whole exists in its ground state. The point is that the property of color is a statistical result of huge numbers of changes going on in the body itself.

8.1.1. Direction There are some things that can be said of all processes just because all of them are the act of something trying to get out of instability to equilibrium. The first of these sounds obvious:

●All processes have a *direction*, and it is always *from* instability *to* equilibrium.

Processes, then, are different from ordinary properties, in that the process is *always headed somewhere*. And since the unstable condition is (by definition) the self-contradictory condition and the equilibrium the condition in which the body can exist, then the *direction* of the process has to be the same in all cases. It could not be the case that a process would start from equilibrium and have as its purpose an unstable condition (i.e. start from a condition that could exist and wind up in a condition that couldn't).

This needs some discussion, however. What of so-called "reversible processes"? For instance, you can combine hydrogen and oxygen and get water; and you can put energy into water and get hydrogen and oxygen out of it. Most inanimate processes, in fact, are like this; they can go in either direction. [This does not seem to be the case in living bodies; if you add energy to a corpse of any living body, it seems not possible to bring it back to life.]

Actually, however, even in these "reversible" processes, the process in question is still going from instability to equilibrium. For instance, if you add energy to a mixture of hydrogen and oxygen, you have made it *unstable,* with a purpose which is *water.* If you then take the *water* (which, of course, is now in equilibrium as water) and add energy to it, then you can *create a new instability in this body,* with now a purpose of being hydrogen and oxygen.

The point is, of course, that you are talking of *two different bodies,* or systems: the hydrogen-oxygen mixture and the water. It turns out that they are so structured that an instability in one has the other as its purpose; and so you can create a process that goes either way, depending on what you have to start with. But in both cases, the process goes from instability to equilibrium, and not from equilibrium to instability.

●There is nothing in the nature of bodies that says that processes have to be reversible.

That is, there is nothing in the nature of a body as such that says that if you set up an imbalance in it with some definite equilibrium as its purpose, you can then set up an imbalance in that resulting body whose purpose will be the bodies you started out with. It often happens; but there is no necessity that it **has** to happen.

And there are two pieces of evidence that seem to indicate that in fact not all processes are of this "reversible" variety. The first, as I already mentioned, seems to be living bodies. Granted, living bodies can reproduce from inanimate materials; and so it is at least thinkable that either inanimate systems or even corpses could be brought into a condition where an instability could be introduced that would start them living—but it never seems to happen outside a living body itself (I except the initial transition from inanimate to living in evolution, because I think there is reason to say that God is involved in this). The second is that the second law of thermodynamics (that changes go from higher to lower energy-states) seems to indicate that in the long run, there is a kind of irreversibility built in even to the reversible processes.

That is, if you are going to get hydrogen and oxygen back from water, you have to put in *more* energy than the energy that was needed to get the water out of the hydrogen and oxygen; in any real-world situation, you can't keep flipping back and forth, saving the energy that was given off in the one case and using it to get back the original stuff. In each case, energy will be dissipated into an unusable form, which means that in the long run, there is a given direction to all processes.

In other words, what the second law of thermodynamics states, really, is that the universe as a whole is unstable, and therefore can trade off some of its "pockets" of high energy to raise lower-energy "pockets" to a higher energy state; but that as it does this, some of this excess energy is lost into the universe itself, making it less capable of doing this the next time. The universe is "running down," going from its (unstable) higher-energy state to a (lower-energy) equilibrium, where all processes will stop.

Why spend so much time on this? Because of time itself. We will see later that "time" is a relation among the quantities of processes, and that the "direction" of time reflects the direction of processes: the past is the "more unstable" and the future is toward equilibrium. Hence, "time reversal" doesn't really make any sense.

You can't, apparently, run the universe in reverse as if it were a film you could rewind, making it go from its more stable to more unstable condition. The fact that *mathematically* time could do this simply shows that mathematics is not necessarily an accurate description of what reality is doing.

No, in all probability, time machines are impossible.

8.1.1.1. Vectors Anyone who has opened a physics book and looked at the formulas has seen the mathematical symbols with the little arrows over them. These are *vectors,* which indicate acts that have not only magnitude but direction.

DEFINITION: A *vector* is a mathematical description of a process or of a tendency toward a process or of the cause of such a tendency.

That is, vectors describe those forms of energy which are processes (that are going *from* something *to* something) because that is the only sort of thing that has a direction. But, of course, since *force* is the action that *causes* a process in something, and since the *being-affected* implies the process in the given direction, then forces and being-affecteds will also have direction, though in a sense they are instantaneous. They have the direction implied by the process they are causing.

That is, the force *creates an instability* in some body, which, of course, sets up a process whose direction is toward the purpose: the equilibirum implied by that particular instability. Hence the instability (the being-affected) has the direction that the process has; and since the force is the cause of this instability, then it also has this same direction to it.

●Equilibrium, since it has no direction, is expressed mathe-

matically as a *scalar* number.

This, of course, is just a number. Energy itself, in general, is expressed in scalar quantities. This does not mean that processes are not forms of energy, but just that in the language physics uses, processes are singled out as "special," and "energy" as such tends to refer to equilibrium.

8.1.2. The quantities of process

Since process **is** a form of energy (i.e. a form of activity, but limited in degree), then it will of course be at least in principle measurable, and will have a quantity. Interestingly, however, a given process will actually have *two* quantities, depending on how you want to look at it.

DEFINITION: The *length* of a process is the *difference in energy* between the initial instability and the final equilibrium.

DEFINITION: The *velocity* of the process is the quantity of the process *as such.*

The length of the process is actually the process looked at in its relation to the body undergoing the process: how far it went, so to speak, from beginning to end. The velocity is the degree of the process *as an act* in its own right: how fast it got there.

The two quantities are actually independent of one another. If you go from Boston to San Francisco, the length of the process is the same whether you go by car or by plane; but the main difference between the two modes of transportation is, of course, that these two processes have different velocities, even though the length may be exactly the same in both cases.

●Notice that the length of a process is a scalar quantity, while the velocity is always a vector.

The reason for that is that the length is simply a difference in energies, while the velocity is the quantity of the process as such, and the process as a process has a direction from the unstable energy-level to the stable one. Hence, it is that quantity of the process which has the vector attached to it.

Note that I am not necessarily talking of *movement* when I am talking of "length of process" or "velocity." *Any* process will have both quantities. The process of blushing, for instance (growing redder) starts from an (unbalanced) initial paleness and ends with a degree of redness; the velocity of the process is how fast it goes from this paleness to the redness.

In fact, there is a question of whether movement in space can be talked of as a process, strictly speaking. If Newton's first law of motion is correct, then movement at a constant speed in a constant direction does not acquire or give up energy, and so would be in reality a (scalar) form of energy (kinetic energy) and not a real process at all. It turns out that this abstraction can't exist, however, and any real movement is a real process involving differences in energy; but will will discuss this at some length later.

●Note that velocities of processes can be directly measured; they need not be arrived at through using time.

That is, the velocity of movement of your car, for instance (what you see as the number on your speedometer), is not arrived at by a little clockwork mechanism. The *change going on* in the wheels as they turn creates a *force* on the instrument, and the *degree* of this force determines how far the needle moves. Hence, the velocity (minus the direction, so strictly speaking, the *speed)* is being *directly* *measured* by the speedometer.

And any process, since it is the activity of something changing (and in inanimate bodies would be the getting rid of energy) can at least in principle do work on something-or-other; and hence can cause a force on some measuring instrument, if you have one that can be affected by the energy being got rid of. Hence, processes are always in principle directly measurable.

DEFINITION: *Acceleration* is the velocity of a *change in velocity.*

There is no law that says that a change has to have a constant velocity; and since the velocity itself can be measured (as, say, 0 mph at the beginning, 5 mph a little later, 55 mph for a hour after that, then down to 25, then back to 0 when you reach your destination), then you can see that there is a kind of sub-process by which the velocity goes from 0 to 55, and another when it goes from 55 back to 0. So the two different velocities describe a "length of change of velocity" and there is a definite *velocity* at which the velocity changed. Suppose you made a jack-rabbit start and got up to cruising speed very fast; but then when you came to the rest area you slowed down very gradually. Your acceleration was much faster than the deceleration (the negative acceleration). Again, the acceleration is independent of the velocities or the "length" of the acceleration as a process.

It is, of course, possible to have variations in acceleration, and to measure those also with a kind of "second order" acceleration emerging as the velocity of *that* change; and sometimes these "velocities of velocities of velocities" have a use in physics, though they don't have any special name.

8.2. Time We have got into the habit of thinking of velocities as relations of distance (length of the process) and time, even though they can be directly measured. How would you talk about the speed of your car except in miles per hour or kilometers per hour or feet per second or some such relation between the length of the movement and the time you took to travel it? There's no such thing as "vels" or something by which you can measure speed.

But this is a pure historical accident. Because Galileo discovered the law of falling bodies by *timing* how far the balls he was rolling down a slope got as he reached different parts of a tune he was singing (since clocks didn't measure time in seconds or even minutes in those days, you had to have something different to do it; and the regular pulse of the rhythm of the song was what Galileo actually used), then Newton took this way of measuring velocity, and time became the "independent variable" that velocity was a "function of." You had your stop watch and you measured speed by noting the length of the process and how far the clock went during the time the process took place.

The reason I mention this is that actually, this is going about things backwards; and—not surprisingly—it introduces unneccessary complications into physics that have persisted to the present day.

What is it you are doing when you time some process? Obviously, you are comparing the *length* of the process with what is going on in your clock, and arriving at the velocity of the process you are interested in. But what is the clock? It could be a sand timer (if you want to measure in multiples of three minutes) or a grandfather clock (if you want to measure in multiples of ticks of the pendulum) or a spring watch (if you want to measure in multiples of ticks of the escapement spring) or a quartz watch (if you want to measure in multiples of the vibrations of the quartz crystal)—and so on.

But what any clock is is *some process that has a constant velocity* and a measurable length. Within the three-minute time of the egg timer, it is useless as a clock, because you can't measure *what part* of the sand has fallen through. Within the ticks of the pendulum, the velocity of the pendulum is not regular, and within the ticks of the watch, the velocity of the process is not regular, and so inside these limits, the instrument is useless as a timepiece. Hence, the characteristic of a clock is that it has a regular or constant velocity. You have to establish this first before you can use anything as a clock to measure time.

●Therefore, "clock's" velocity must be known (at least as constant) before time can be measured.

Hence, what you are doing is starting the clock's process at some known point (turning the timer over, noting the position of the hands or the numbers) together with the beginning (the imbalance) of the process to be measured, and stopping both processes together (either actually as with a stopwatch or mentally, noting the position of the hands). You then come up with the following ratio:

$$L_c/V_c = L_p/V_p$$

That is the length of the clock's process is to its (constant) velocity as the length of the measured body's process is to its (average) velocity. Since the velocity of the clock's process is constant, the only thing that varies on the left-hand side is the length of the process. Since you know this, and since you know the length of the process on the right-hand side, then the one remaining quantity (the velocity of the body) *is now known in relation to the LENGTH of the clock's process.*

That is, you don't need to know the *actual velocity* of the clock, as long as it is constant and as long as you don't use different clocks to measure processes. There are two variables on the right, and only one on the left, and the *ratio* of the two variables is equal.

Hence, if one of the variables on the right is known (the length), then the unknown can be expressed as a function of the length on the right—which is also known.

●Timing a process, therefore, is comparing the *ratio* of the length to the velocity of the process to the *ratio* of these two quantities of some standard process (with a constant velocity).

Hence:

DEFINITION: The *time* of any process is the *ratio* of its length to its velocity.

That is, what is going on in "timing" can now be seen to be comparing the time *of the process you are measuring* to the *time of the standard process*. So there are actually *two* times involved: the clock's and that of whatever you are measuring; and what these times are (we can see from our thought-experiment) in each case is simply the relation between the two quantities of the process.

Now we come to something that seems controversial. Since there is *no real connection* between the two quantities of any process (i.e. the length does not depend in any way on the velocity or vice versa), this ratio is just a chance number that happens to express what the ratio is in a given case, or in other words,

●*Time* is *not* something real.

That is, what you are measuring with your clock is not *as such* something real. There is a real velocity, and there is a real length to both the process you are measuring and the process you are using to measure it (your clock), but the ratio between these two quantities is just a mathematical trick, describing *no relation* that actually obtains in the objects (i.e. no activity of one on the other; that's what a *real* relation always is).

That is, it makes no difference to the length of the process you are timing that it has a certain velocity; it could have any velocity at all, and the length would be the same. And the same is true of the velocity; the same average velocity is not affected in any way by the fact that the process was this or that length. Hence, there is no connection in reality between the length of the process and the velocity; and so the time of the process as such is not a real relation.

●Time is a mental relation which has a foundation in reality; but the relation itself does not exist.

The foundation for our making the comparison exists; but the two numbers (the quantities) are just different—allowing us to divide one by the other. But the number that results from this division is *not* the quantity *of anything at all;* it is simply a number that **we** can arrive at by comparing two quantities.

If this is true of the time *of* a process, then the time that is "the same" in the clock and the measured process is *a fortiori* not real. That is, you say the clock took "the same time" to make a revolution of the minute hand as the car took to go 30 miles at its 30 mph constant velocity. The ratios are the same; but these ratios are not the quantity **of** any form of energy; they are simple numbers. And so "the same time" is a second-order relationship: you compare the ratio (L/V) of one with the ratio (L/V) of the other, and notice that the relation of these two ratios is that the numbers are the same; and so that is supposed to be the "time," as if you actually measured "something." But if you measured something, what is it? Where is it?

This is why "time" in that "the same time" sense appears as "between" things in a kind of "space" that isn't really the space between things. It's a kind of imaginary "line" that stretches from "the past" through "the present" to "the future," along which line "events occur," and which you measure the "length" of by using your clock.

But there's no such line, of course, and you get into all sorts of conundrums, as St. Augustine did, if you try to say that there is. Obviously, "the past" doesn't exist any more, so how could it be measured? And "the future" doesn't exist yet, so you can't measure **it** either. The only thing that exists is "the present"; but this has to be the present *instant,* which, of course is only a *point* along this "line," and so it has no length. So if time is real, it is unmeasurable.

●Hence, time in the sense of the comparison of various times (ratios within processes) is not real either.

8.2.1. Complications in physics

This theory of time would predict that it wouldn't just be St. Augustine who got into trouble considering time, but that if physics takes time as the "independent variable" for measuring velocity, then it would be likely that some strange conclusions could result.

And in fact, as the Special and General Theories of Relativity have shown, this does really happen. The two theories, in fact, have a lot to do with just exactly the realization that one person's clock is not measuring "the same time" as another's—unless they are at rest with respect to each other.

Einstein supposed (for reasons that have an experimental foundation in attempts to discover the velocity of light) that the velocity of light in a vacuum was always the same, and would always be observed to be the same (differences due to whether you are moving to or away from the light source show up as different *wave lengths* of the light, not different velocities).

Now then, with that in mind, suppose you and I are comparing our clocks. We are at rest with respect to each other, and I note that they are synchronized. As my watch's hands come back to the 12, yours also are exactly on the 12.

But now let us let one of us move past the other with a constant velocity. If I am going to observe your clock as it moves past me, I am going to have to do it by means of the light which is traveling (at a constant velocity) between your clock and mine. But since the *distance the light travels* is *changing,* then the *time* the light takes to get from your clock to mine is changing (because the velocity of the light does not change). Hence, a *second time* is now introduced, which is going to mean that, if our clocks *appear* to be on the 12 together at the start of the measurement, the light that left your clock when it was at the twelve *actually* arrived at my clock slightly later (because of the transmission-time), but at the time it arrived, my clock said exactly 12 (supposing, as I said, that they were synchronized). But now when my clock says 12:05, for instance, then the information from your clock has had to travel *a different distance* to get to my clock; and so I will *not now be able to read your clock as saying 12:05.* Our clocks cannot now be seen to be synchronized, because I am reading your clock with the interference of a *second* process whose length is changing.

The result, says Einstein in the Special theory, is that the person who considers himself at rest (and the other one as moving with respect to him) will see the other clock as *going slower* than his.

But since neither one can claim to be "really" at rest (the only thing that is happening is that the distance *between* them is changing, not that one is necessarily "there" someplace in "absolute space"), then *each observer will observe the other clock as going slower than his.* That is, A will say that B's clock is going slower; but B will not say that A's is going faster, but will *also* observe A's as going *slower*. (Because, of course, the information from A's clock takes time to get to B.)

8.2.1. Complications in physics

This is really strange if the clocks are actually measuring something; but of course they aren't; they are simply making ratios. But the relation between my ratio and yours is fouled up by the process of information-transfer.

Of course, if the clocks are at rest with respect to each other, then the information going from one to the other always takes the same time (same length, same velocity); and hence, those two clocks can be synchronized. But not if one is moving with respect to the other.

It is also true that if *acceleration* is taken into account, then this variation in the time of information-transmission becomes extremely complicated; and so the relation between the processes becomes that much more bizarre. This is perhaps not the place to go into this here; but what it amounts to is that these wierd conclusions (that twins, for example, would wind up different ages if one blasted off on a trip and—having gone *very* fast—came back again) are due to the fact that you are making comparisons of quantities of processes with processes involved in the transmission of the information necessary to make the comparisons.

Einstein also points out that observations of *simultaneity* are different depending on motions of the observers. If asteroids hit both ends of a rocket ship moving by another rocket ship, let us say that those people in the middle of the ship struck observe both hits as happening together. But astronauts in the ship going by will have the light transmitted different distances to their eyes from the events, and will see one as happening before the other. Then did they really hit the ship at the same time or not? You can argue this way: If the ship was moving, and on the ship they were observed to hit simultaneously, then the rearmost one would have had to hit the ship slightly before the foremost one; but if the ship was not moving "really," (and only the other one was), then they "really" hit at the same time. But—as we will see more at length—you can only establish movement the way you establish position; with respect to something real, and the only other object to use is the other ship; and so it is a tossup which is "really" moving if the distance between them is changing. Hence, there is no absolute meaning to "simultaneous" any more than there is to any other time-word.

I hasten to say that the Theories of Relativity do *not* establish that "everything is relative"; they even *presuppose* that the velocity of light in space is *not* relative to the observer. Nor is motion as such relative if the distances between objects change; what is relative is *which* of the objects is considered to be moving and which is "at rest" and what the time of the movement of "the other system" is. The relativity here is analogous to considering whether, when you grew an inch, your feet went an inch farther down from your head or your head went an inch farther up from your feet.

8.2.2. Newton's physics and time

Let me show what happens to Newton's physics because of the introduction of time as an "independent variable," using his force equation.

$$F = ma$$

Now acceleration, for Newton, is the *time*-derivative (tendency to change) of velocity, which is the *time*-derivative of distance. It looks like this when you put it in the form of the calculus:

$$F = m \; d^2x/dt^2$$

In order to solve this equation, you have to do some fairly complicated integrating, because you have a "second derivative" (those superscripts aren't squares). But if you note that

$$v = dx/dt$$

and

$$a = dv/dt$$

and you solve for dt, you get

$$dt = dx/v = dv/a$$

Eliminating dt, and bringing the v's together on one side, you get

$$a\ dx = v\ dv$$

Solving for a, so you can substitute for it in the force equation, you have

$$a = v\ dv/dx$$

Substituting:

$$F = m\ v\ dv/dx$$

Or, separating the variables:

$$F\ dx = m\ v\ dv$$

Which directly integrates into:

$$F\ @\ x = mv^2/2,$$

which is Newton's work-energy formula.

So a simple substitution for acceleration, once you have eliminated the unnecessary dt from the equation, gives you the force equation directly integrable into the Newtonian form; but this takes several complicated steps in Newton's own way of doing it, precisely because he has used the time, and without realizing it had to perform several operations whose only real function was to eliminate the superfluity.

PREDICTION: This view of time predicts that much of physics could be simplified if time were eliminated as an "independent variable" from the equations of physics.

People might object that you can't observe processes and measure their velocities unless you use clocks. My contention is that velocities can be measured directly, without the use of clocks. For instance, you can measure the velocity of the process of heating by making the *increase* of heat cause pressure on an instrument (analogously to the speedometer of a car). Perhaps this would involve devising new instruments; but they don't seem to me to be that difficult to invent. It's just that no one has seen the need to do so so far.

And what I suspect, based on this view of time, is that much of the mystery of calculations would drop away; and it is quite conceivable that the elimination of time would show that classical physics and relativistic physics are actually just the same thing at base; and the difference between them depends on what you do with that pesky variable time, which really makes no difference to what you are observing, because what it "measures" is really nothing at all.

You can see that the philosophy of nature is not simply a description of what scientists have discovered about bodies; it is a science in its own right, with consequences that matter to the other sciences that deal with bodies. It might very well be that if philosophers and scientists could learn to cooperate, instead of having scientists look indulgently on philosophers as playing interesting but irrelevant games, both disciplines would be better off.

In any case, my theory is on the line, now. I have made predictions, which should be testable by anyone who wants to make the effort to test them.

8.2.3. The calculus Let me say a brief word about the differential and integral calculus, which really belongs to the philosophy of mathematics, but is in place here, in a sense.

The way the mathematicians explain a derivative like 30 mph (i.e dx/dt = 30 mi/hr) is that the dx is the limit you reach when taking a distance a making it smaller and smaller until it becomes an arbitrarily small "delta" (*) below any "epsilon" (g) which is as small as you want to name. As you make the distance smaller and smaller, then (supposing the ratio to be either constant or varying continuously), the "length of time" it takes to go that distance gets smaller and smaller in the proper ratio, so that it too ultimately become arbitrarily small—*but* the ratio is preserved even here. Then there is the leap to the "limit": that if it keeps getting that way, then "in the limit" (if the distance covered could get to zero, which it can't), then the ratio would be what the "little tiny" one is (or is headed towards).

Where I would differ from this is the notion that, mathematically speaking, the limit can't be reached and the derivative deals with "little tiny" finite quantities. The reason it is said that the limit can't be reached is that the denominator would then actually **be** zero, and division by zero is forbidden (because there's no inverse operation).

But, mathematically speaking, "little tiny" numbers (your epsilons and deltas) that are "right next to zero," are nonsense. *Any* finite quantity is an "infinite way" away from zero, because there's an infinity of (finite) numbers between it and zero. After all, one foot is a "little tiny" quantity when you're talking about the distance between here and the nearest star (some 3 trillion miles), but it's a huge quantity when you're talking about the distances you measure with a micrometer.

However, there is *one* case where division by zero is meaningful: 0/0. The inverse operation x · 0 = 0 works in this case—except that x can be any number you want.

What I think the calculus is saying is that when there is a function that *converges* on a definite value as you *approach* 0/0, *then* the fraction has a definite meaning: the value that is approached.

This may be just a different way of reading the meaning of "limit"; but it is certainly not what some mathematics professors understand by it. In any case, it makes the derivative an exact number, *expressing the* tendency *to change at some point,* and not a ratio between "little tiny" differences in an "infinitesimal change." And it is this tendentical reality (force or being-affected) that the derivative refers to.

8.3. The path of the process

Before we get into movement as a process, there is one other aspect of processes in general to consider. It does not follow that the length of a process (in the sense of the difference in energy levels between the beginning and end points) is the same as the "distance traveled" to get there.

The length would describe the *net work done* in the process; but this could involve work being done *on* the affected object, and work being done *by* it for a while, and then work being done *on* it again. What I am talking about can be described in terms of movement most easily. The distance from Boston to Los Angeles is, say, three thousand miles. But if you go from Boston to Los Angeles by way of a trip to Miami, then up to Chicago, and so on, you're going to travel a good deal more than three thousand miles. So the distance traveled and the distance between the end-points need not be the same.

Similarly, if you're heating something, then if you heat it and let it cool and heat it again, then net gain in temperature (the length of the process) is, say, 100 degrees; but it cooled down during part of this process, spilling its heat into the environs; and so the process of heating took a longer *path* to get between the end-points. Or again, the path by which you get from the beginning balance in your check book to the ending balance is usually considerably longer (because of deposits as well as withdrawals) than the length of the process (the difference between the two balances).

Sometimes, the path of a process is significant in physics, sometimes (because there is no *net* difference between it and the length) it is not. In any case, what the path amounts to is that the process can be (at least in thought) broken up into smaller processes with different directions (and hence different beginnings and endings) and then these smaller processes can be added up vectorially into the total process.

8.4. Movement There remain two topics in this sketch of the philosophy of bodies: movement and evolution. The first is interesting in that there is a question of whether movement is a process at all or not.

The reason is Newton's first law of motion: a body at rest will remain at rest, and a body in motion will remain in motion at a constant velocity (speed and direction) unless acted on by an "unbalanced" force. This implies that there is no change in energy in a moving body (if it is moving with a constant velocity), and hence no **real** process. It is one of those acts (if this "law" is true) that expresses an apparent process which is really an act.

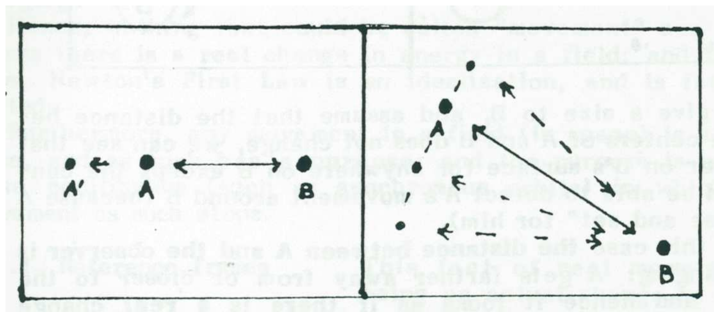
But the fact that Einstein's General Theory of Relativity precisely *denies* that this law is true should give one pause. True, Einstein says that movement with a constant *acceleration* needs no "force" and hence is not a process, and constant velocity would be a constant acceleration of zero; so the first law is a kind of limiting case of Einstein's supposition. But the denial as Newton stated it means that the law is at least worth examining.

Now on the supposition that position "in absolute space" is meaningless, and position in reality is being affected *by some body's field,* it follows that *motion is always motion in the field of some real body.* This, of course, what Einstein would say also; there is no meaning to "absolute motion" without reference to some "reference frame," which in the real world is some body with a field.

What we want to find out is whether there could be anything which could meaningfully be observed as motion which would not involve *change in energy-level* in a field. If everything observed as motion involves changes in the energy-level of the field-interactions of the two objects, then a *real change* has occurred (there has been work done and a transfer of energy), and motion would be a real process, needing a force of some sort to account for it.

Let us now set up some thought-experiments. First, consider that there are only two objects in the universe, each of which has no size (so that they have no "sides"), but are mass-points; let us for simplicity consider only the gravitational field-interactions of these.

Now if the distance between A and B changes, so that A gets farther from or closer to B, the effect of B's field on A is going to change, and this is a real change in energy. Hence, if there is to be motion without a real change, the distance between A and B would have to be constant.

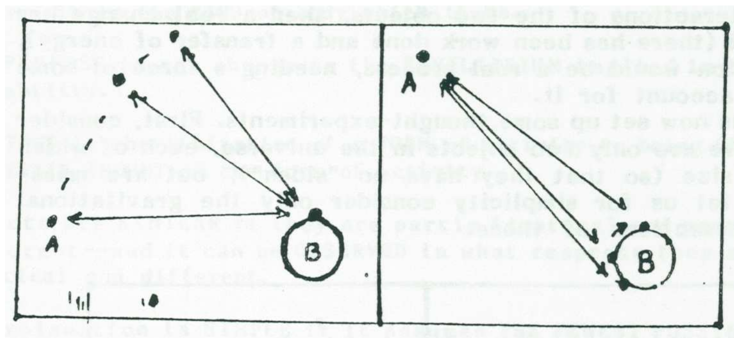


You would think that A could move in a circle (actually a sphere) around B, and still leave the distance (the radius of the sphere) constant. But the question is this: Could this "movement" be observed by B as a movement? Or by A?

Remember, there are no "sides" to either B or A, *and there is no other point of reference in this universe,* so that there is nothing in B to establish a "direction" *except* A. So if A "moved" around B, *B would not be able to observe it.* Nor could A, because the only direction it could establish would be that toward B; but *in the direction toward B, there is no change.* Hence, only an ideal observer somewhere in "absolute space" would be able to tell that A is moving; that is, only from a *third object* could A be said to be moving around B.

We actually are making ourselves a third object when we take this "universal" point of view and suppose that A is "really" moving around B when neither A nor B could say so. But this supposes that motion “in absolute space” means something or that A is moving **with respect to us.** But then there aren’t just two objects in the universe.

If we give a size to B, and assume that the distance between the *centers* of A and B does not change, we can see that an observer on B’s surface (or anywhere on B except the center) would be able to detect A’s movement around B (because A would “rise and set” for him).



But in this case *the distance between A and the observer is really changing:* A gets farther away from or closer to the observer; and hence it looks as if there is a *real* change going on.

You might argue that there isn’t, because the changes in distance on each side of the center cancel each other out, so that there is no net change, really. But there is; and we can see what it might be if we look at the movement from A’s point of view.

A has no “sides,” so that A can’t tell that it is going around B; and the distance between A and B as a whole does not change; and so you woud think that from A’s point of view, no change would be observable. But this is not so. A would observe *B as rotating,* with the observer coming round periodically. There is no real difference in this case between A's going round B and B's rotating.

If there are real field-interactions going on between A and B, then what is going to happen is that (like the real pendulum as opposed to the "perfect" one) either the revolution of A around B (or the rotation of B below A) will tend to slow down (because the changing energy-levels of the parts of B are pulling at A in the direction opposite to the revolution—or are making B rotate more slowly). And the purpose of the process of slowing down is, of course, having A in a synchronous orbit, so to speak: that is, when the revolution/rotation slows so that A is *observably at rest* above some point on B, the system will be in equilibrium, and any disturbance either way will have a tendency to right itself.

But when A is revolving at exactly the same rate as B is rotating, then no motion can be observed; and supposing there to be no "absolute observer" or third object, no definable movement occurs; and all distances are now fixed.

Of course, if we introduce a third object, then from that point of view A could be observed revolving around B. But a little thought will show that *this could only happen if the real distance between A (and/or B) and this third object are changing.*

Hence, nothing that could be called "movement" can occur unless there is a *real* change in energy in a field; and therefore, Newton's First Law is an idealization, and is false as stated.

Furthermore, any movement in a field (in space) is a *process,* and as such *has a purpose;* and the purpose is always some equilibrium (such as synchronous orbits) in which the movement as such **stops.**

8.4.1. Reference frames This fact of real movement's being an actual change in energy-levels in a field accounts, perhaps, for the odd geometry of Einstein's "paths of movement in space-time." The Einsteinian physics is complicated by the fact that what Einstein was

8.4.1. Reference frames

interested in was not only establishing that there was no "absolute space" with reference to which things were "really" moving and no "absolute time" in which they did it; but to make this fit with the fact that *distances are real and do not depend on the observer.*

The whole of the very complex tensor calculus was developed, not to show that distances are *relative,* but to have a mathematical system which would leave *the distance between* two objects the same *no matter what reference frame you were on,* and no matter how it was moving with respect to any other one.

What is a reference frame? You must have seen those little diagrams with an x-axis, a y-axis, and a z-axis with reference to which you could locate points. This is a Cartesian reference frame, invented by Rene Descartes (Latin: Cartesius). But there are other "coordinate systems," such as polar coordinates, spherical coordinates, and so on, which don't use axes at right angles to each other. We don't need to add confusion by describing them.

What they all are are conveniences for locating objects in the "space" defined by the coordinate system. What Einstein was concerned about is that if you have two observers who are moving with respect to each other, each one's coordinate system is going to measure funny things in the other coordinate system, since the other one is moving and distances *between* it an the other observer are changing. Then if each of the observers observes two objects, the observations of the two will be different because of the changing distances between the objects and the observers and between the observers and each other.

Einstein's mathematics allows the observers on either reference frame to correct for the motions of the other one and to make observations which will make sense also in the other reference frame (making the proper corrections there). This had to be done, because he assumed that there is *no* "privileged" reference frame; every one is as good as every other one. *That* is what is relative about relativity;

it does *not* really deal with the relativity of *what is observed*.

But why does Einstein talk about space-*time* and not just space? Because motion of the reference-frames is involved. And, again not to bore you with the mathematics behind this, if you take the "fourth dimension" of Einstein's space-time (x y z and t), the time-dimension, you find that it isn't just plain old t, but involves a negative product of the velocity of light and time (which is a velocity divided by a distance), and so turns out to be an *adjustment of distance,* not a time at all.

This was necessitated by the observed sameness of the velocity of light in any reference frame; the reference frame would have to have its distances adjusted in the direction of its motion in order to have the measurement of light come out right.

But once again, time has reared its ugly head, complicating things. And so I offer the following

PREDICTION: It should be possible to develop a way of dealing with the real distances between objects in terms of the forces acting on each other, and to describe movements as the changes of these field-interactions without resorting to "reference-frames"; if this were done, many other complications in physics would disappear.

This is a much more tentative proposal than any of the others I have made. My attempts to verify it have run into the difficulty one who has any experience in physics has of describing things without referring to some reference frame; like King George's head in *David Copperfield,* the reference frames keep intruding themselves.

I would venture to say that if something like this could be done, then we would find macroscopic physics looking remarkably like quantum physics also. I suspect that classical and relativistic physics look the way they look because of the parameters they introduce; and these parameters might very well (especially in the case of time) be unneccessary.

PREDICTION: Instead of taking mass, length, and time as "primitive concepts," and defining everything else with reference to them, this theory would predict a simpler physics if *energy, velocity, and force* were taken as "primitive," and length, mass, time, and all other concepts were derived from them.

Mathematically, of course, there is no trouble doing this, because if A is equal to B, then you can make B equal to A; it is really just turning the equations inside out (as I did with the force equation, eliminating the time). I suspect that if you did a thorough job of this, you would find the mathematics of physics to simplify itself considerably, because you would be dealing with what is really "out there" (and directly measurable) and not something which is actually at a second remove from what you are observing.

8.4.2. Movement and Zeno

The ancient philosopher Zeno proposed a number of paradoxes which were intended to prove that movement was simply a way **we** considered things and was not a real change at all. It is instructive to see if our notion of movement as a real change can survive his critique.

If, says Zeno, you are going to move across the room, you have to move half way before you get to the other side. But in order to get to the half-way point, you first have to move half of *that* distance; and in order to get *there,* you first have to move half of *that* distance, and so on to infinity. No matter how small a distance you move, you first have to cover half of it before you can get there—and half of that, and half of that, and so on. So you can't really move.

Or you can take it the other way. If you get half way, you have to cover half of the remaining distance before you get to the other side, and then half of the now remaining distance, and so on; you never can get there, because you always have half of the remaining distance left.

What is the solution? Zeno is looking at a movement as if it were *a series of smaller movements.* That is, he is mentally *stopping* the movement at the half-way point, and then stopping it again at the next half-way point, and so on.

But if movement is a *real* change, it starts with a *definite* instability, which implies a definite purpose. So that if you are moving across the room, your body has an instability in it whose purpose is *the other side,* not half-way. So the instability does not reach a mini-equilibrium halfway across and then resume its trek.

That is, the movement across the room is a *single act,* not a series of lesser acts; it is a *unit,* and though you can *consider* it (because of its *path)* as a series of smaller movements, it does not *exist* as a set of acts, but as one single act with two limits and only two: the imbalance and the equilibrium.

Hence, Zeno confuses the path of the movement with the act of moving; it looks paradoxical, but the movement actually has meaning only as *a* between of the two limits.

And this would add fuel to what I said about the macroscopic world's being like that of quantum mechanics. In quantum mechanics it seems quite clear that changes in energy and movements and so on have to be taken as "between" limits but without all the "intermediate fractions" of a kind of continuous path between the two limits. Perhaps what happens in quantum physics is that the nature of what is being described does not allow of the fiction of reference-frames and continuous spaces and infinitely divisible lines and so on, but deals with acts between definite limits; and the change is describable only in terms of the limits, not something intermediary.

My prediction above probably would have something like this happen in the macroscopic description of things, if you eliminate reference-frames. Possibly the orbits of planets would involve the energy-levels in solar space in which the planets exist, but where the planet is at any moment in this energy-level would not be detectable; it would just be "somewhere on this level."

I don't know. Conceivably, a physics in terms of energy, velocity, and force as primitive concepts, without time and reference frames, would not be able to be developed, or if able to be developed, would not work. It would be interesting to try, however, to see if some of the unsolvable knots in contemporary physics might just turn out to be a tangle in the thread of the investigative process itself—and this would unravel it.

8.5. Evolution I promised at the very beginning I would say something about evolution. I have a set of notes I hope to work up into decent form some day called "Hypothesis for the Universe" in which I sketch what evolution should look like based on the conclusions I have come to on the nature of bodies, change, process, and life. [Since I first wrote this, the I put the hypothesis as Volume 7 of *Modes of the Finite*.]

Basically, if evolution is a process, then it started with an instability, and is headed toward an equilibrium. Thus, the universe began in an unstable condition, and the "heat death" is its predictable outcome.

If it began as unstable, then there was something outside the universe that accounted for it. I assume that this is the Infinite Act, God (what else could it be?). But since God is absolutely unchangeable (though He can cause change), then what happens in the universe He creates cannot make a real difference in Him, and therefore the creation and sustaining of the universe is an act of absolute **love** on His part. As I tried to show in *The Finite and the Infinite,* God can know the universe He creates without actually being dependent on it or changing (he knows it insofar as He knows Himself as causing it).

I think the evidence supporting evolution is so overwhelming that, even if in details it is wrong, it has to be basically on the right track. To deny it in favor of some literalist interpretation of the Bible is to abdicate reason altogether (in which case, why believe the Bible?).

But **if** the universe caused by God is evolving, and is in a process, and if God is causing the process, my hypothesis is this:

●**Evolution is a gradual unfolding of *love* in two senses: of God's love (respect) for the universe He creates, and of love (unselfishness) *in* the universe itself.**

That is, this hypothesis predicts that as the process goes on and bodies are more and more capable of doing more and more for themselves, God will manipulate things less and less and leave them more and more free and responsible for what they do; and also, as the process goes on, you will find things acting more and more explicitly **not** for self-fulfillment, but in imitation of their Divine Creator, who is lavish in giving and not seeking return.

I am not going to try to verify this here; as I say, I have a sketch of it that gives me some hope that it might be on the right track, and it looks as if it can be shown without forcing the data into a kind of Procrustean mold; and it turns out to be beautiful and somewhat hopeful (though not as hopeful as Teilhard de Chardin, I am afraid; I don't see the end, now that humans are free, as inevitable—and given what happened to Jesus, there's reason to doubt the inevitability; but God can write straight with crooked lines.).

But I leave this treatment of bodies here, in this extremely incomplete state. There may be a few things I have said that are true, and they might provoke a further search by those who have more insight than I; and if anything I have said turns out to be productive of light on the subject of bodies, then all the errors and silliness of the rest of what has been put down here can perhaps be forgiven.

8.5. Evolution

GLOSSARY OF TECHNICAL TERMS

ACCELERATION is the velocity of a CHANGE IN VELOCITY.

An ACCIDENTAL change occurs when the body becomes different, but remains the same SUBSTANCE (i.e. KIND of body).

The AFFECTED OBJECT is THE CONCRETE THING that contains the effect as PART of itself.

Objects are ANALOGOUS if they are partly identical and partly different, but the RESPECTS in which they are identical and different ARE NOT KNOWN FROM OBSERVATION.

ANGLE is the COMBINED distance of from two objects to a third.

A situation is called BAD when the facts contradict the way we expect them to be, and WE REFUSE TO ACCEPT THEM.

BEING-AFFECTED is the RELATION between the EFFECT

AND THE CAUSE. It is the same as the causality, but looked at in the other direction.

BEING is the object of consciousness.

CAUSALITY is the RELATION between the cause and its effect. It is the WAY IN WHICH the cause makes sense out of the effect.

The CAUSE is the TRUE EXPLANATION: it is the FACT which in fact makes sense out of the effect. The CAUSE contains ONLY WHAT IS NECESSARY to make the effect not a real contradiction.

The EFFICIENT CAUSE is the external energy which is introduced into a body, making it unstable.

The CAUSER of a given effect is THE CONCRETE OBJECT or set of objects which are doing the causing: that is, which CONTAIN the cause AS PART OF themselves.

A CONDITION is cause of a cause.

A CONTRADICTION is something that is both true and false.

SCIENTIFIC CURIOSITY is puzzlement when confronted with a set of facts that seem to contradict each other.

ABSTRACT REAL DISTANCE is the CAUSALITY of a "unit" field on a "unit object." Or, alternatively, DISTANCE is the FORCE of a field AS SUCH.

CONCRETE REAL DISTANCE is the actual force some object's field is exerting on some real object.

An EFFECT is a set of facts which, taken by themselves, contradict each other.

The EFFECT is JUST THE FACTS that make up the contradiction (it contains nothing that is not part of the puzzle itself).

ENERGY is any activity that is limited BOTH in form and in quantity.

EQUILIBRIUM is the condition in which the form of the unifying energy of a body has the matter appropriate to it.

The EVIDENCE for the truth of a statement is some admitted fact which COULD NOT BE A FACT if the statement in question were FALSE.

EXISTENCE is the cause explaining the fact that we are conscious-of rather than imagining.

A scientific EXPERIMENT is a procedure set up to determine if the hypothesis actually does explain the effect as observed.

An EXPLANATION is a POSSIBLE SITUATION which, if it were a fact, would make the effect make sense.

A FIELD is a form of energy which has an infinity of quantities all at once.

FORCE is the CAUSALITY energy exerts on some affected object.
FORCE is CAUSALITY AS QUANTIFIED.

The FORM OF ACTIVITY [FORM OF EXISTENCE] is whatever it is about the activity [existence] that allows it to be known as a KIND of activity or existence.

A situation is called FUNNY when the facts contradict the way we expect them to be, and we SIMPLY RECOGNIZE THE SITUATION.

A HYPOTHESIS is an explanation of the effect in question, which will be tested to see if it is the one which is actually the fact which makes sense out of the effect.

INSTABILITY is the condition in which the form of the unifying energy has a matter that is incompatible with it.

A LAW is a constant relationship that obtains in reality.

The LENGTH of a process is the DIFFERENCE IN ENERGY between the initial instability and the final equilibrium.

The NATURE of a body is the body AS revealed in its properties, or AS "capable" of performing the properties.

The term NATURE used absolutely (i.e. not the "nature of X") refers to the sum of all bodies that are not man-made.

The OBJECT of consciousness is the causer whose effect is an experience-of.

An OPERATIONAL or CAUSAL DEFINITION of something is a definition of the cause of some particular effect as “the whatever-it-is-that-causes-this-effect.”

The ABSTRACT REAL POSITION of an object is its BEING-AFFECTED by another’s field as such. That is, it is The degree to which it would be being-affected if it were a unit object in a unit field.

The CONCRETE REAL POSITION of one object with respect to another is its ACTUAL BEING-AFFECTED by the field of the other.

The POTENTIAL of a field is ONE of its ACTUAL quantities.
A PREDICTION from a scientific theory is AS YET UNOBSERVED IMPLICATION from what the theory asserts as the “cause” of the original effect.

A PRACTICAL PROBLEM can be stated as the following type of contradiction: “I intend to do X; the facts I know indicate that it is not possible for me to do X.”

A THEORETICAL PROBLEM is the same as an EFFECT.

PROCESS is a change AS a property of some body.

A PROPERTY of a BODY is ANY act that the body performs as a body.

An INTRINSIC PROPERTY is a property that the body exhibits by its own activity in itself, NOT as a REACTION to some energy acting on it.

A REACTIVE PROPERTY is a property that the body exhibits when RESPONDING to some energy acting on it.

A PROPERTY of a SUBSTANCE is some activity that a body does because it is the KIND of body which it is.

The PURPOSE in any change is the EQUILIBRIUM implied in the instability.

QUANTITY is the limitation of a FORM of activity to being ONLY A CERTAIN AMOUNT of the form of activity.

Objects are SIMILAR if they are partly identical and partly different—and it can be OBSERVED in what respects they are identical and different.

An explanation is SIMPLE if it assumes THE FEWEST POSSIBLE facts that are not directly in evidence.

SPACE as a whole is THE SUM OF ALL POSITIONS.

The SPACE AROUND an object is the object's FIELD.

SPECULATION is the discovering of an explanation for a given effect.

Speculation is SCIENTIFIC SPECULATION if the explanation is checked to see that it is (a) internally consistent, and (b) that it does indeed explain all the observed details of the effect.

Activity that is NOT limited quantitatively is called SPIRITUAL activity.

A SUBSTANCE is a KIND of body.

A SUBSTANTIAL change occurs when the body becomes a different SUBSTANCE (i.e. KIND of body).

A THEOREM is a statement that is necessarily true just because of the way the terms involved in it are defined.

A THEORY is a detailed statement of what is thought to be the cause of the effect in question.

The TIME of any process is the RATIO of its length to its velocity.

A VECTOR is a mathematical description of a process or of a tendency toward a process or of the cause of such a tendency.

The VELOCITY of the process is the quantity of the process AS SUCH.

VERIFICATION is the process of observing to see whether predictions from the theory are actually facts or not.

WORK is energy AS the effect of some other energy.

WORK is any complete measurable change.