CHAPTER XVII

ON THE NOTIONS OF ‘MATTER’, ‘SPACE’, ‘TIME’

Common sense starts with the notion that there is matter where we can get sensations of touch, but not elsewhere. Then it gets puzzled by wind breath, clouds, etc., whence it is led to the conception of “spirit”—I speak etymologically. After “spirit” has been replaced by “gas,” there is a further stage, that of the aether. (457)

BERTRAND RUSSELL

The supposition of common sense and naive realism, that we see the actual physical object, is very hard to reconcile with the scientific view that our perception occurs somewhat later than the emission of light by the object; and this difficulty is not overcome by the fact that the time involved, like the notorious baby, is a very little one. (457) BERTRAND RUSSELL

We have certain preconceived ideas about location in space which have come down to us from ape-like ancestors. (149) A. S. EDDINGTON

But it does not seem a profitable procedure to make odd noises on the off-chance that posterity will find a significance to attribute to them. (149)

A. S. EDDINGTON

There is a blessed phrase “hidden reserves”; and generally speaking the more respectable the company the more widely does its balance-sheet deviate from reality. This is called sound finance....Thanks to Minkowski a way of keeping accounts has been found which exhibits realities (absolute things) *and balances.* (149)A. S. EDDINGTON

The quest of the absolute leads into the four-dimensional world. (149)

A. S. EDDINGTON

The views of space and time which I wish to lay before you have sprung from the soil of experimental physics, and therein lies their strength. They are radical. Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality. (352) H. MINKOWSKI

It is a *thing;* not like space, which is a mere negation; nor like time, which is-Heaven knows what ! (149) A. S. EDDINGTON

Newton objectivises space. Since he classes his absolute space together with real things, for him rotation relative to an absolute space is also something real. (151)A. EINSTEIN

Space is only a word that we have believed a thing. (417) H. POINCARÉ

In fact, our ordinary description of nature, and the idea of exact laws rests on the assumption that it is possible to observe the phenomena without appreciably influencing them. (215) W. HEISENBERG

Even when this arbitrariness is taken into account the concept “observation” belongs, strictly speaking, to the class of ideas borrowed from the experiences of everyday life. It can only be carried over to atomic phenomena when due regard is paid to the limitations placed on all space-time descriptions by the uncertainty principle. (215) W. HEISENBERG

Section A. Structural considerations.

The facts at hand in 1933 show that the language we use for the purpose of describing events *is not* the events; the representation symbolizes what is going on inside our skins; the events are outside our skins and *structural similarity* is the only link between them. Historically, as a race, we learned sooner and more about the events outside our skins than about the events inside our skins; just as a fish or a dog 'knows' a lot about his world, lives sometimes happily and abundantly, and yet 'knows' nothing about biology, or physiology, or psycho-logics. Only recently did we begin to sturdy ourselves scientifically. At some stage of our development, we introduced structurally simple forms of representation, such as a *language* of subject-predicate, of additivity, . We are still perplexed when we find that the events outside our skins cannot be pressed into schemes which are manufactured inside our skins. Our nervous system, with its ordered and cyclic structure and function, manufactures abstractions of different orders, which have quite distinct structure and different characteristics. On different levels, we manufacture different abstractions, dynamic and static, continuous and discontinuous. , which have to take care of our needs. If the verbal schemes we invent do not fit structurally the world around us, we can always invent new schemes of new structure which will be more satisfactory. It is not a problem of the world around us, for our words cannot change that, but of *our ingenuity*. In the meantime, we learn something very important; namely, about the world's *structure*, which is the only content of knowledge.

There are good structural reasons why the world should, or should not, be accounted for in terms of differential equations, or in *terms and language* of 'causality', . The term *order* is structurally fundamental and will help us in a radical and constructive way, in our quest.

First, however, we will investigate some further semantic problems, remembering that a theory of sanity, which means a theory of adjustment, should emphasize the methodological and structural means for such semantic adjustment. The dynamic-static translations are fundamentally connected with different orders of abstractions and involve psycho-logical issues connected with 'emotions' and 'intellect', linearity versus non-linearity, 'straight' versus 'curved'. , explained in Parts VII and VIII.

.In life, as well as in science, we deal with different happenings, objects, and larger or smaller bits of materials. We have a habit of speaking about them in terms of 'matter'. Through a *semantic disturb-*

ance, called identification, we fancy that such a thing as ‘matter’ has separate physical existence. It would probably be a shock to be invited seriously to *give* a piece of ‘matter’ (give and *not* burst into speech). I have had the most amusing experiences in this field. Most people, scientists included, hand over a pencil or something of this sort. But did they actually give ‘matter’ ? What they gave *is not* to be *symbolized* simply ‘matter’. The object, ‘pencil’, which they *handed*, requires linguistically ‘space’; otherwise, there would be no pencil but a mathematical point, a fiction. It also requires verbally ‘time’; otherwise, there would be no pencil but a ‘flash’.

Similarly, if any one is invited to *give* a piece of ‘space’ (again *give* it, and *not* burst into speech), the best he could do would be to wave his hand and try to show ‘space’. But the waving of the hand referred to what we call air, dust, microbes, gravitational and electromagnetic fields, . In other words, structurally, the supposed ‘space’ was *fulness* of some materials already ‘in space’ and ‘in time’.

In the case of *giving* ‘time’, one could *show* his watch. A similar objection holds, also; namely, that he has shown us so-called ‘matter’ which is ‘moving’ in ‘space’. It is very important to acquire the *s.r* that when we use the term ‘matter’ we refer to something, let us say, the pencil, which, according to the accepted *el language*, also involves ‘space’ and ‘time’, which we disregard. When we use the term ‘space’, we refer to a fulness of some materials, which exists in ‘time’. But because these materials are usually invisible to the ‘senses’, we again disregard them. In using the term ‘time’, we refer to ‘matter’ moving in ‘space’, which again we disregard.

What is said here and what will follow is structurally unconditionally fundamental for a theory of sanity, because in most cases of ‘insanity’ and un-sanity, there is a disorientation as to ‘space’ and ‘time’. In identification, the semantic disturbance which affects nearly all of us, and is at the foundation of the majority of human difficulties, private or public, there invariably appears a special semantic disorientation in our feelings toward ‘matter’, ‘space’, and ‘time’. This is only natural, for the ‘insane’ and un-sane are the unadjusted; the ‘sane’ are the supposedly adjusted.

Adjusted to what ? To the world around us and ourselves. Our *human* world differs from the world of animals. It is more complex and the problems of human adjustment become also more subtle. In animal life, attitudes toward the world do not matter in a similar sense; with us, they become important; hence the need of analysis of the new human ‘semantic universe’, which involves the ‘universe of discourse’. This

‘universe of discourse’ is strictly connected with the *terms* of ‘matter’, ‘space’, and ‘time’, structure, and our semantic *attitude* toward these terms.

Let us return to the analysis of our object which we call the ‘pencil’. We have seen that the *object* pencil *is not* ‘matter’, nor ‘space’, nor ‘time’. A question arises, which has been asked very often and has *never,* to my knowledge, been answered satisfactorily: what ‘is’ the *object* pencil, and what ‘are’ the *terms* ‘matter’, ‘space’, and ‘time’ ? Here and there some one has given fragments of answers or some satisfactory detached statements. But in every case I know, the semantic disturbance called identification appears, and so even the casual correct answer is not applied but remains enmeshed in some other identifications. I have spent much ‘time’ and labour in overcoming my own identifications, and now confront the situation that nearly every work I read from this point of view cannot be criticized, but requires rewriting. This task is impossible for me, technically and otherwise. So, finally, I decided to formulate the present $\overline{A}$-system, and then see what kind of reconstruction can be accomplished with the new evaluation.

The answer to the questions set above is childishly simple, yet I will carry it all through and let the semantic consequences speak for themselves. The chunk of nature, the specially shaped accumulation of materials. , which we call a pencil, ‘is’ fundamentally and *absolutely un-speakable,* simply because whatever we may *say* about it, *is not it.* We may write with this something, but we cannot write with its name or the *descriptions* of this something. So the object *is not words.* It is important that the reader be entirely convinced at this point, and it requires some training, performed repeatedly, before we get our *s.r* adjusted to this simple fact. Our statement had two parts. One was rather-unpromising; namely, that the object was absolutely un-speakable, because no amount of words will make the object. The other was more promising, for we learned an extremely important, perhaps crucial, semantic fact; namely, what the *object* pencil *is not;* namely, that the *object is not words.* We must face here an important semantic fact. If we are told that we cannot get the moon, we stop worrying about it, and we regard any dream about getting the moon as an infantile phantasy. In this example, we could not even say that such news as the impossibility of getting the moon was sad, or unpleasant, news. We might say so, jokingly, to an infant, but the majority of the grown-ups would not have their *s.r* perturbed by it. A similar situation arises with the object called pencil. The *object is not words.* There is nothing sad or depressing about this fact. We accept it as a fact and stop worrying about it, as

an infant would. The majority of the old ‘philosophical’ speculations about this subject belong to the semantic period of our infancy, when we live in phantasies and structurally gamble on words to which we affectively ascribe objective existence, . This represents full-fledged un-sanity due to identification. The answer to the question, what ‘are’ the *terms* ‘matter’, ‘space’, and ‘time’, is, as usual, given in the properly formulated question. They ‘are’ *terms,—’Modi considerandi’,* as Leibnitz called them without fully realizing the semantic importance of his own statement. Incidentally, it must be noticed that it was the psycho-logical characteristic of Leibnitz who was capable of such a statement, that was probably responsible for his whole work, as will become more apparent later on. When we abandon primitive standards of evaluation, geniuses will be *made* by a semantic education which relieves the race from the older blockages.

So we see clearly that outside of our skins there is something going on, which *we call* the world, or a pencil, or anything, which is *independent* of our words and which is *not* words. Here we come across a very fundamental irreversible process. We can say that in this world a man and his words have happened. There is a ‘causal’ eventual complex series between the world, us, and our words, but in unaided nature this process is, in the main, irreversible, a fact unknown to primitives who believe in the magic of words. Through our ingenuity we can make this process partially reversible; namely, we can produce gramophones, telephones in all their developments, electromechanical men who obey orders, .

We know in 1933 that in the semantic world this process is dramatically effective. Words are the result of the activity of one organism, and they, in turn, activate other organisms. On the macroscopic level of ordinary behaviour, this last was known long ago, but only in the last few years has psychiatry discovered what kind of semantic and psychophysiological disasters words and their consequences may produce in the human organism. These last are already on sub-microscopic levels, not obvious and, therefore, only recently discovered.

The structure of the language of ‘matter’, ‘space’, and ‘time’ is ancient. The primitive saw something, ate something, was hurt by something, . Here was an occasion for a grunt of satisfaction, or of pain. The equivalents of words like ‘matter’, ‘substance’. , originated. Neither he, nor the majority of us, realized that the small or large bits of materials we deal with appear as extremely complex *processes* (explained in Part X). For him, as for most of us, these bits of materials ‘are’ ‘concrete’, whatever that means, and he might know ‘all about them’, which

must have led to identification. , and other delusional evaluations. Of course, these were phantasies of human infancy, and, in lives lived in a world of phantasies, adjustment, and, therefore, sanity, is impossible. Since he did not see or feel, or know about the material he was immersed in, the *fulness* he was living in, he invented the term ‘space’, or its equivalent, for the *invisible* materials which were present. Knowing nothing of fulness, he objectified what appeared to him to be empty space, into ‘absolute emptiness’, which later became ‘absolute space’, ‘absolute nothingness’, by ‘definition’.

There are several important remarks which can be made about this ‘absolute emptiness’ and ‘absolute nothingness’. First of all, we now know, theoretically and empirically, that such a thing does not exist. There may be more or less of something, but never an *unlimited* ‘perfect vacuum’. In the second place, our nervous make-up, being in accord with experience, is such that ‘absolute emptiness’ requires ‘outside walls’. The question at once arises, is the world ‘finite’ or ‘infinite’ ? If we *say* ‘finite’, it *has* to have outside walls, and then the question arises: What is ‘behind the walls’ ? If we say it is ‘infinite’, the problem of the psycho-logical ‘walls’ is not eliminated, and we still have the semantic for walls, and then ask what is beyond the walls. So we see that such a world suspended in some sort of an ‘absolute void’ represents a *nature against human nature,* and so we had to invent something *supernatural* to account for such assumed nature against human nature. In the third place, and this remark is the most fundamental of all, because a symbol must stand for something to be a symbol at all, *‘absolute nothingness’ cannot be objective and cannot be symbolized at all.* This ends the argument, as all we may say about it is neither true nor false, but *non-sense.* We can make noises, but say nothing about the external world. It is easy to see that ‘absolute nothingness’ is a *label for* a *semantic disturbance,* for verbal objectification, for a pathological state inside our skin, for a fancy, but not a symbol, for a something which has *objective* existence outside our skin.

Some other imaginary consequences of this semantic disturbance are far-fetched and very gloomy. If our world and all other worlds (island universes) were somehow suspended in such an ‘absolute void’, these universes would radiate their energy into this ‘infinite void’, whatever that means, and so sooner or later would come to an end, their energy being exhausted. But, fortunately, when we eliminate this pathological semantic state by proper education all these gloomy symptoms vanish as mere fancies. It must be noticed that this ‘absolute space’, ‘absolute void’, ‘absolute nothingness’ with its difficulties, which are due

to very primitive structural speculations on *words,* and to some un-sane ascribing of objectivity to words, can be abolished quite simply if we decide to investigate and re-educate our *s.r.*

What we know positively about 'space' is that it is not 'emptiness', but 'fulness', or a 'plenum, . Now 'fulness' or a 'plenum', first of all, is a term of entirely different *non-el* structure. When we have a plenum or fulness, it must be a plenum of 'something', 'somewhere', at 'some time', and so the *term implies,* at least, *all three of our former elementalistic terms.* Furthermore, fulness by some psycho-logical process does not require 'outside walls'. If we ask if such a universe of fulness is 'finite' or 'infinite', without any psycho-logical difficulties, we may reply that we do not know, but if-we study enough of the materials of this universe we *may know. A* universe of fulness may be assumed to have boundaries, and then we may ask again the annoying question: What is beyond ? With the proper use of *language,* this difficulty is again eliminated.

Without going into unnecessary details, we see that a boundary, or a limit, or a wall, is something by *definition,* beyond which we cannot go. If there is nothing to restrict our progress, there are no *boundaries.* Let us fancy some cosmic traveller with some extraordinary flying machine, and let us assume that he flies without stopping in a 'definite direction'. If he never encounters any boundary, he is surely entitled to say that his universe is unbounded. The question may arise: Is such an unbounded universe finite or infinite in size ? Again let us apply correct language and a little analogy. A traveller on a sphere, like our own earth, could travel *endlessly* without ever coming to a boundary, and yet we know that the sphere, our earth, is of finite size. Mathematicians have worked out this point, and it is embodied in the Einstein theory. The universe is unbounded, an answer which satisfies our feelings; yet it is finite in size, although very large, an answer which satisfies our rationality.[*] The visualization of such a universe is quite difficult. It should not be visualized as a sphere, but, at a later stage, we will see that it *can* be visualized satisfactorily. The condition for visualization is to eliminate identification, that *semantic disturbance* which is strictly connected with primitive ways of 'thinking'.

The problems of 'time' are similar, although they have a different neurological background. The rough materials we deal with mostly affect our sight, touch, . Invisible materials, like air. , affect these 'senses'

[*] I do not introduce here the latest speculations in this field, because, from a non-aristotelian point of view, they appear meaningless.

less, but more the kinesthetic ‘senses’ by which muscular movements are appreciated, and so ‘space’ and ‘time’ have different neurological backgrounds. ‘Time’ seemingly represents a general characteristic of all nervous tissue (and, perhaps, living tissue in general) connected with summarizing or integrating. What we have to deal with in this world and in ourselves appears as periods and periodicity, pulsations, . We are made up of very long chains of atomic pulsating clocks, on the sub-microscopic level. On the macroscopic level, we have also to deal with periodic occurrences, of hunger, sleep, breathing, heart-beats, . We know already that, beyond some limits, discontinuous times, when rapid enough, are blended into continuous feelings of pressure, or warmth, or light, . On objective levels we deal with times, and we feel ‘time’, when the times are rapid enough.

Again, the moving pictures are a good illustration. The normal moving-picture film shows sixteen pictures a second. The film gives us static pictures with finite differences. When we put it on the projector, the differences vanish. Our nervous system has summarized and integrated them, and we see ‘continuous motion’. If pictures are taken at the rate of eight a second and then run on the normal projector for the speed of sixteen a second, we summarize and integrate again, but we see a fast moving picture. If the pictures are taken at the rate of 128 exposures a second and run on the normal projector of sixteen pictures to a second, we have what is called a slow moving picture. It should be noticed that the order of the semantic rhythmic processes is fourfold; it involves order not only in ‘space’ (three dimensions) but in ‘time’ also. Periods of contraction alternate with periods of rest, and this occurs at nearly regular intervals.

This rhythmic tendency is, indeed, so fundamental and so inherent in living tissue that we can, at pleasure, make voluntary muscles; for example, exhibit artificially induced rhythmic contractions by immersing them in special saline solutions, as, for instance, a solution of sodium chloride. We should also not wonder why modern science assumes that life may have originated in the sea. The physico-chemical conditions of saline solutions are such that they favour rhythmic processes; they not only may originate them, but may also keep them up, and life seemingly is very closely connected with autonomous rhythmic processes.

Such rhythmic processes are *felt* on lower orders of abstraction as ‘continuous time’, probably because of the rapidity and overlapping of periods. On higher order abstractions, when structurally proper linguistic and extra-neural means are developed, they appear as times.

Perhaps, neurologically, animals *feel* similarly as we do about ‘time’, but they have no neurological means to elaborate linguistic and extra-neural means which alone allow us to extend and summarize the manifold experience of many generations (time-binding). They cannot pass from ‘time’ to ‘times’. Obviously, if we do not, we then renounce our human characteristics, and copy animals in our evaluating processes, a practice which must be harmful.

In nature the visible and invisible materials seemingly consist of recurring pulsations of extremely minute and rapid periods, which, in some instances, become macroscopic periods. In the first case, we cannot see them or feel them, so we talk about ‘concreteness’, . In the second case, we see the periodic movements, as of the earth around the sun. , or we feel our heart-beats, . We see that the visible or invisible materials in nature are compounded of periodic pulsations and are simply two aspects of one process. The splitting of these processes into ‘matter’, ‘space’, and ‘time’ is a characteristic function of our nervous system. These abstractions are *inside* our skins, and are methods of representation for ourselves to ourselves, and *are not* the objective world around us.

It must be realized that under such circumstances we cannot speak about ‘finiteness’ or ‘infiniteness’ of ‘matter’, ‘space’, and ‘time’, as all the old ‘philosophers’ have done, Leibnitz included, because these terms ‘finite’ and ‘infinite’, though they may be conceivably applied to *numbers* of aspects of objective entities, have *no meaning* if applied to linguistic issues, that is, to *forms of representation* outside of numbers. Of course, if, through a semantic pathological disturbance (objectification), we do ascribe some delusional objective existence to verbal terms, we can then talk about anything, but such conversations have no more value than the deliria of the ‘mentally’ ill. The terms ‘finite’ or ‘infinite’ are only legitimately applied to *numerical* problems, and so we can speak legitimately of a finite or infinite numbers of inches, or pounds, or hours, or similar entities, but statements about the ‘finite mind’ or the ‘understanding of the infinite’. , have no meanings and only reveal the pathological semantic disturbance of the patient.

The objectification of *our feeling* of ‘time’ has had, and has at present, very tragic consequences strictly connected with our un-sanity. It must be remembered that particularly in ‘mental’ and nervous difficulties the patient seldom realizes the character of his illness. He may feel pains, he may feel very unhappy, and what not, but he usually does not understand their origin. This is particularly true with semantic disturbances. One may explain endlessly, but, in most cases, it is perfectly hopeless to try to help. Only a very few benefit. Here lies, also, the

main difficulty in writing this book. Readers who identify, that is, who believe unconsciously with all their affective impulses in the objectivity of ‘matter’, ‘space’, and ‘time’, will have difficulty in modifying their *s.r* in this field.

Let us see now what consequences the objectification of ‘time’ will have for us. If we do *not* objectify, and *feel* instinctively and permanently that words *are not* the things spoken about, then we could not speak about *such meaningless* subjects as the ‘beginning’ or the ‘end’ of ‘time’. But, if we are semantically disturbed and objectify, then, of course, since objects have a beginning and an end, so also would ‘time’ have a ‘beginning’ and an ‘end’. In such pathological fancies the universe must have a ‘beginning in time’ and so must have been made. , and all of our old anthropomorphic and objectified mythologies follow, including the older theories of entropy in physics. But, if ‘time’ is only a *human form of representation* and *not an object*, the universe has no ‘beginning in time’ and no ‘end in time’; in other words, the universe is ‘time’-less. It was not made, it just ‘was, is, and will be’. The moment we realize, feel permanently, and utilize these realizations and feelings that words *are not* things, then only do we acquire the semantic freedom to use different forms of representation. We can fit better their structure to the facts at hand, become better adjusted to these facts which *are not* words, and so evaluate properly *m.o* realities, which evaluation is important for sanity.

According to what we know in 1933, the universe is ‘time’-less; in other words, there is no such *object* as ‘time’. In terms of periods, or years, or minutes, or seconds, which is a *different language*, we may have infinite numbers of such times. This statement is another form of stating the principle of conservation of energy, or whatever other fundamental higher abstraction physicists will discover.

Because ‘time’ is a *feeling*, produced by conditions of this world outside and inside our skins, which can be said to represent times, the problem of ‘time’ becomes a neuro-mathematical issue. It must also be noticed that times, as a term, implies time*s* of something, somewhere, and so, as with plenum or fulness, it is structurally a *non-el*, $\overline{A}$ term.

Time*s* has also many other most important implications. It implies *numbers* of times, it implies periods, waves, vibrations, frequencies, units, quanta, discontinuities, and, indeed, the whole structural apparatus of modern science.

Euclidean ‘space’ had the semantic background of ‘emptiness’. In it we moved our figures from place to place and always assumed that this could be done quite safely and accurately. Newtonian mechanics

also followed this path and even postulated an ‘absolute space’ (emptiness). All of which harks back to the old aristotelianism.

$\overline{E}$, $\overline{N}$, and $\overline{A}$ systems have the semantic background of fulness or plenum, although, unfortunately, this background is, as yet, mainly unrealized, not fully utilized; it has not, as yet, generally affected our *s.r*.

A simple illustration will make the difference clear. Imagine that in one part of a large room we have an open umbrella which we would like to compare with another ‘unit’ open umbrella. Let us imagine that the room has the air pumped out and also that all other eventual disturbing factors are eliminated. We can move our open ‘unit’ umbrella from one part of the room to another, and this movement will not considerably distort our ‘unit’ umbrella. Now let us perform a similar experiment in two houses, separated some distance, during a storm, a storm implying, of course, *fulness.* Can we transport our ‘unit’ umbrella through the storm and preserve its shape. , in a fulness, without-taking the fulness into account ? Of course not. We see what serious difference it makes if our theories presuppose ‘emptiness’ or ‘fulness’.

This shows also why the non-euclidean geometries which deal with a plenum are structurally preferable and semantically sounder and more in accord with the structure of the world, than the language of euclidean ‘emptiness’, to which there is nothing in nature to correspond. Should we wonder that modern linguists (mathematicians) work in the direction of fulness and of fusing geometry with physics. It is obviously the only thing to do. Differential geometry is the foundation of this new outlook, but, even in this geometry, lines could legitimately be transported over great distances. Weyl introduced a semantic improvement of this point of view by assuming that for a differential geometry it is illegitimate to use comparisons at large distances, but that all operations should be between indefinitely near points.[1]

It should be noticed that scientists, in general, disregard almost completely the verbal and semantic problems explained here, a fact which leads to great and unnecessary confusion, and makes modern works inaccessible to the layman. Take, for instance, the case of the ‘curvature of space-time’. Mathematicians use this expression very often and, inside their skins, they know mostly what they are talking about. Millions upon millions of even intelligent readers hear such an expression as the ‘curvature of space-time’. Owing to nursery mythology and primitive *s.r*, ‘space’ for them is ‘emptiness’, and so they try to understand the ‘curvature of emptiness’. After severe pains, they come to a very true, yet, for them, hopeless, conclusion; namely, that ‘curvature of emptiness’ is either *non-sense* or ‘beyond them’, with the semantic result that either

they have contempt for the mathematicians who deal with non-sense or feel hopeless about their own capacities—both undesirable semantic results.

The truth is that ‘curvature of emptiness’ has no meanings, no matter *who* might say it, but curvature of fulness is entirely different. Let the reader look at the cloud of smoke from his cigarette or cigar, and he will at once understand what ‘curvature of fulness’ means. Of course, he will realize, as well as the mathematicians do, that the problem may be difficult, but, at least, it *has sense* and represents a problem. It is not non-sense.

Similar remarks apply to higher dimensions in ‘space’. Higher dimensions in ‘emptiness’ is also non-sense; and the layman is right in refusing to accept it. But higher dimensions in fulness is entirely a different problem. A look at the cloud of smoke from our cigarette will again make it completely plain to everybody that to give an account of fulness, we may need an enormous number of data or, as we say roughly, of dimensions. This applies, also, to the new four-dimensional world of Minkowski. It is a fulness made up of world lines, a network of events or intervals. , and it is not non-sense.

Lately, there has appeared an excellent book by Bertrand Russell, published by the International Library of Psychology, Philosophy and Scientific Method; and yet the title is *The Analysis of Matter*, without any quotation marks.

This book is really an unusually fine and fundamental work which has no defects which could be implied by the title. This title simply disregards the issues explained here; it should be *The Analysis of ‘Matter’*.

It is with some pleasure that one sees such an authority as Eddington, in his *The Mathematical Theory of Relativity*, on p. 158, making the statement: ‘In using the word “space” it is difficult to repress irrelevant ideas; therefore let us abandon the word and state explicitly that we are considering a *network of intervals’*.

For the reasons already given, I do not use the terms ‘matter’, ‘space’, or ‘time’ without quotation marks; and, wherever possible, shall use, instead, the terms ‘materials’, ‘plenum’, ‘fulness’, ‘spread’, and ‘times’, (say seconds). Indeed, these semantic problems are so serious that they should be brought to the attention of International Mathematical and Physical Congresses, so that a new and *structurally correct* terminology could be established. It is *not* desirable that science should *structurally mislead* the layman and disturb his *s.r*. It is easier for trained specialists to change their terminology than to re-educate semantically the rest of the race. I would suggest that terms ‘matter’, ‘sub-

stance', 'space', and 'time' should be completely eliminated from science, because of their extremely wide-spread and vicious structural and so semantic implications, and that the terms 'events', 'space-time', 'material', 'plenum', 'fulness', 'spreads', 'times'. , be used instead. These terms not only do not have the old structural and semantic implications, but, on the contrary, they convey the *modern* structural notions and involve new *s.r*. The use of the old terms drags in, unconsciously and automatically, the old primitive metaphysical structure and *s.r* which are entirely contradicted by experience and modern science. I venture to suggest that such a change in terminology would do more to render the newer works intelligible than scores of volumes of explanations using the old terminology.

Before summarizing in Parts IX and X what modern science has to tell about the structure of the world around us, it will be profitable to enquire what are the means by which we can recognize this structure.

Section B. The neurological function of abstracting.

Protoplasm, even in its simplest form, is sensitive to different mechanical and chemical stimulations; and, indeed, undifferentiated protoplasm has already all the potentialities of the future nervous system. If we take an undifferentiated bit of protoplasm, and some stimulation is applied to some point, the stimulus does not spread somehow 'all over at once', with some mysterious 'infinite' velocity, but propagates itself with finite velocity and a diminishing gradient from one end of our bit of protoplasm to the opposite end.

Because of the *finite velocity* of propagation and the fact that the *action is by contact in a plenum*, the impulse has a definite direction and diminishing intensity, or, as we say, the bit of protoplasm acquires a temporal polarity (head-end). Such polarity conditions produce a directed wave of excitement of diminishing intensity, which Child calls a dynamic gradient. If such a stimulation were applied to one spot for a considerable length of 'time', some kind of polarization may become lasting. In some such way those dynamic gradients have become *structuralized* in the forms of our nervous system, which represent the preferred paths by which the nervous impulses travel.

The bodies of most organisms are protected from outside stimulation by some kind of membrane or cuticle and the parts of the surface have developed so as to be sensitive to one form of stimulation and not to others. For instance, the eye registers the stimulations of light waves, while it is insensitive to sound. , and, even if hit, it gives only the feeling of light. Each 'sense-organ' has also the nervous means of concentrating

stimuli, intensifying them. , and so of effecting the most efficient response of the corresponding end-organ.

In our school days we were taught that we have five ‘senses’. Modern researches show that there are more than twenty different ‘senses’. Besides, as far as ‘Smith’ is concerned, we know that ‘senses’ and ‘mind’ cannot be divided.

The main stimulations which we find in the outside world may be divided into three groups. The first are connected with the roughest macroscopic manifestations of the outside world; they are mechanical impacts which we abstract as ‘tactile sensations’, which range from a single mechanical contact to rhythmically repeated contacts with our skin as frequently as 1552 vibrations per second. Above this limit ‘times’ begin to be registered as a ‘duration’; that is, the individuality of ‘times’ is lost, and we feel pressure. At this level we deal with gross macroscopic manifestations, which are not only felt but can also be seen.

The second group of manifestations is, in the main, no more on the gross level. Here belong the vibratory manifestations which are no more visible to the unaided eye. We may speak of them as on the microscopic level. They are mechanical vibrations of the air. , and we become acquainted with them in the form of sound. The vibrations which the average ear is able to register range from about 30 (sometimes even 12) to about 30,000 or even 50,000 vibrations a second. The ear does not register any other vibrations.*

The third group of vibratory manifestations belongs to a still subtler level. They are electromagnetic waves of an enormous variety of wavelengths and number of vibrations per second. The lower members of this series are the Hertzian electric waves, the higher members are the X-, or Röntgen-rays. Our nervous systems are capable of registering only a very limited range of these vibrations; namely, the waves called radiant heat, the light waves, and the ultra-violet rays, these last only on a chemical level. It seems that we have no organ which responds directly to electric waves, ultra-violet rays, X-rays, and the many other rays which we know from laboratory work.

Similarly, the chemical ‘senses’ of taste and smell register only a very small number of actual excitations to which they are exposed.

Animals have different limits of nervous susceptibility, but we can have no idea how the world looks to them unless their nervous system is quite similar to our own. The above statements will become clearer if we tabulate some of them. The following table is taken. from *An Introduction to Neurology* by Professor C. Judson Herrick, p. 85 (Fifth Edition):

* Latest researches seem to modify these data.

TABLE OF PHYSICAL VIBRATIONS*

[figure]

*The use of names for large numbers is not uniform in different countries, and so I give, in brackets, the United States and French equivalents to the English names.

Millions 1000000 = 10^6; (million).

Milliard 1000000000 = 10^6; (billion or milliard).

Billion $10^6 \times 10^6 = 10^{12}$; (trillion).

In this table 1 billion = 10^9.

As a further illustration of the mechanism of abstracting, we may suggest the observation of Weber that if, for instance, a room is lighted with 100 candles, and if one more candle is brought in, the increased illumination will be appreciated very slightly. But not so if we had a room illuminated with 1000 candles. In this case, we should not appreciate the addition of one candle at all. Ten candles should be introduced to make an appreciable difference in our perceptions. The Weber law, as it is called, stated that in the above case 1/100 of the original strength of the stimulus is needed to make a change appreciable. For light, the fraction is about 1/100; for noise, about 1/3; for pressure, it varies between 1/30 and 1/10; for weight, between 1/70 and 1/40 in various parts of the body.

If we use compasses and experiment with pricks, we find that in different parts of the body the limit of the distance apart of the points when we *feel one prick* and yet have two, is different.

On the tip of the tongue this limit is	1 mm.
On the palmar surface of third phalanx of forefinger	2 mm.
On the palmar surface of second phalanges of fingers	4 mm.
On the palm of the hand	10 mm.
On the dorsal surface of first phalanges of fingers	14 mm.
On the back of hand	25 mm.
On the upper and lower parts of forearm	37 mm.
On the middle thigh and back	62 mm.[2]

A ‘sensation’ requires appreciable ‘time’ (times by a clock) for its development. Part of the ‘time’ is spent at the end-organ, part in conveying the nervous impulse along the nerves to the brain and part in the brain. A ‘sensation’ usually outlasts the stimulus, and often a single stimulus produces a whole series of ‘after-sensations’.

As compared with the ‘sensations’ obtained from pain spots, touch is quicker in its development and persistence. With a vibrating string, 1500 vibrations a second are recognizable by touch as vibrations. At over 1552 vibrations a second, the vibratory character is lost, and we feel only continuous pressure. A toothed revolving wheel gives the feeling of smoothness (and ‘continuity’) when the teeth meet the skin at the rate of from 480 to 680 per second.[3]

The above given tables and facts are deeply significant. We see, first of all, that structurally we are immersed in a world full of energy manifestations, out of which we abstract directly only a very small portion, these abstractions being already coloured by the specific functioning and structure of the nervous system—the abstractors. Very probably, there are many more energy manifestations which, as yet, we have not

discovered. Every few years we discover some new form of energy manifestation, and, at present, our knowledge is already so advanced that it is highly probable that the list is much longer. Finally, and here the whole 'structure of human knowledge' begins to play its role; for sanity *we have to know and evaluate this world* around us, if we want to adjust ourselves satisfactorily to it.

Section C. Problems of adjustment.

Is the problem of adjustment in the animal world similar to that in the human world ? No, it is entirely different. Animals do not alter their environment so rapidly, nor to such an extent as humans do. Animals are not time-binders; they have not the capacity by which each generation can start where the former left off. Neurologically, animals have no means for extra-neural extensions, which extensions involve the complex mechanism with which we are dealing throughout this work.

The example of the caterpillar, already cited, shows clearly how organisms not adapted to their environment perish and do not propagate their special, non-survival characteristics. Similar remarks apply to hens, their eggs, and chicks which are kept in buildings without sunlight or with ordinary glass windows; these, also, do not survive, and so pass out of the picture.

With humans, the situation is entirely different. We are able to produce conditions which do not exist in unaided nature. We produce artificial conditions and so *our numbers and distribution* are not regulated by unaided nature alone. Animals cannot over-populate the globe, as they do not produce artificially. We do over-populate this globe because we produce artificially. With *animals, selfishness comes before altruism, and the non-selfish perish. An animal has to live first, then act.* With man, the reverse is true. The selfish may produce such conditions that they are destroyed by them. We can over-populate the globe because of artificial production, and so we are actually born nowadays into a world where we must *act first before we can live.* As I have already shown in my *Manhood of Humanity* (p. 72), the old animalistic, fallacious generalizations have been, and are, the foundation of our 'philosophies', 'ethics', systems. , and naturally such animalistic doctrines must be disastrous to us. Neurologically, we build up conditions which our nervous systems cannot stand; and so we break down, and, perhaps, shall not even survive.

Animals have no 'doctrines' in *our meaning* of the term; thus, doctrines are no part of their environment, and, accordingly, animals cannot perish through false doctrines. We do have them, however, and,

since they are the most vital environmental semantic conditions regulating our lives, if they are fallacious, they make our lives unadjusted and so, ultimately, lead to non-survival.

So we see that ‘human adjustment’ is quite a different and much more complex affair than ‘animal adjustment’. The ‘world’ of ‘man’ is also a different and much more complex ‘world’ than that of the animal. There seems to be no escape from this conclusion. We see, also, that what we used to call ‘senses’ supply us with information about the world that is very limited in quantity, *specific* in quality, an abstraction of low order, never being ‘it’. Being often unaffected, our ‘senses’ are not able to abstract, obviously, some of the most fundamental manifestations of energy to be found in the external world. If we speak of the older so-called ‘sense perceptions’ as lower order abstractions, then we find that we learn about the other subtler manifestations of energy through science, higher neural and extra-neural means, which we may call higher order abstractions. In the older days, we called this kind of knowledge ‘inferential knowledge’. The animals do not have these higher order abstractions in that sense, and so their world is for them devoid of these extra-sensible manifestations of energy.

It must be remembered that these higher order abstractions and the ‘inferential knowledge’ of the old theories (they are not equivalent by definition) have a very similar status. Organisms work as-a-whole, and to separate completely higher and lower order abstractions is impossible. All that is said here justifies the new terminology. Our nervous system does abstract, does summarize, does integrate on different levels and in different orders, and the *result* of a stimulus *is not* the stimulus itself. The stone *is not* the pain produced by the stone dropping on our foot; neither is the flame we see, nor the burn we feel. The actual process goes on outside of our skin, as represented by the ‘realities’ of modern science.

We have already spoken frequently of the different order abstractions, their special characteristics, dynamic versus static. , and the means of translation of lower orders into higher, and vice versa. Events which are going on and for which we have no direct ‘senses’ of abstraction, as, for instance, electric waves, Röntgen-rays, wireless waves. , we know only through extra-neural extensions of our nervous system given by science and scientific instruments. Naturally, we should expect that the structure of our abstracting mechanism would be also reflected in these higher order abstractions. Facts show this to be true; and practically all modern science proves it directly or indirectly. This is why, for instance, we have the mathematical methods for passing from dynamic

to static, and vice versa; why we have quantum theories and conditions; and why we have problems of continuity versus discontinuity, atomic theories, .

The above is not a plea for certain old-fashioned ‘idealistic philosophies’ and still less for ‘solipsism’. Far from it. The object of this present work is to face hard structural experimental *m.o* facts, analyse these facts in a language of a similar *structure* ($\overline{A}$), and so to reach tentatively new conclusions which again can be verified by experiments. Once more the reader must be warned against carelessly translating the structurally *new* terms into the *old* terms. The complete structural, psycho-logical, semantic, and neurological analysis of one single such new term would afford material for several volumes and so is impossible in this work. The usefulness of the old terms has been exhausted. The structural consequences of the old terms have been practically all worked out, and, as a rule, we cannot have much quarrel with the older conclusions in the *old language.* If we reach *different* conclusions, or get some new emphasis, it will be due-to the use of the structurally new language. If we translate the new into the old, the old conclusions are usually *truer* than the new ones. The reverse is also true; the old conclusions become false or, at best, only gain emphasis because of the structure of the new language. The problem of all theories, old or new, is to give a structural account of the facts known, to account for exceptions, and to predict new experimental structural facts which again may be verified empirically.

Section D. Semantic considerations.

We speak much and vaguely about the ‘structure’ of language, but extremely little work has been done in this field. In the present work, we not only tackle this problem as best we can, theoretically, but we also use a language of a new *non-el,* functional structure, and the results, whatever their value, are actually the results of such procedure.

A short while ago we did not even know that such problems existed. Dreams, alone, about such problems did not help, for, before the structures of two different entities can be compared, these entities must first be produced. Then, and only then, can we compare and evaluate them. Before we could compare the *A,* the *E,* and the *N* systems with $\overline{A}$, $\overline{E}$, and $\overline{N}$ systems the last had to be produced, no matter how imperfect they might be at the beginning.

Something similar can be said about languages. Before we can speak of them in the plural and compare them, we must have more than one for comparison. Mathematics has pointed out this problem for us in

geometry. For instance, we have to deal with different frames or references, or different systems of co-ordinates. We find that they represent different languages and that they may introduce purely verbal statements which have nothing to do with the subject of our analysis (extrinsic characteristics). We have also found that some characteristics may appear in one form of representation and not appear so readily in another. For instance, we know that every line, except the X axis through a point 0 which is the intersection of a parabola with its X axis, cuts the curve a second time. This fact, important for us to know, appears clearly in the polar co-ordinate form of representation, but does not appear in the rectangular form of equations, although, when once a characteristic of a curve is discovered, it can be usually translated into the other co-ordinate languages. In such cases as this, a language of new structure has a kind of creative character, in that it makes some structural discoveries easier.

But the co-ordinate methods were not quite satisfactory. They introduced, too easily, too many extraneous, extrinsic characteristics, belonging to the language and not to the subject. Mathematicians decided to get away from these metaphysical 'outside' references by referring the entity to itself to become more experimental. They invented the internal theory of surfaces, a vector language where they *refer the entity to itself,* its curvature, its length and direction. Finally, in the extension of the vector language which is called the tensor calculus, they achieved a still larger kind of independence. Having invented *three* languages in which we can speak about *one* issue, we are now able to meet the problem of *comparison* of these languages. At once, most important structural and methodological problems arise.

The newer quantum mechanics are also an epoch-making linguistic structural innovation, not only in physics, but also in *methodology.* We have, at present, three, or, perhaps, more, quantum mechanics which speak about one subject, but in entirely different languages. I say 'three or more', because, from a methodological point of view, it is very hard, at present, to be precise, as the problems are too new and, as yet, too little analysed. Similar remarks apply to systems. Before two systems can be compared, a second system must be produced. Then we can compare them.

In our brief verbal analysis of 'space', and 'time', and 'matter', we have seen that these represent *terms,* or *linguis*tic *means, not objects.* We have seen, also, that these antique forms of representation have very unsatisfactory structural implications. They introduce a verbal *elementalism* structurally *absent* in nature, and by a process of objecti-

fication lead to many kinds of fanciful semantically harmful metaphysics. Since Einstein and Minkowski, the excellent term ‘event’ has been introduced into scientific literature. It is a term of such epoch-making semantic importance that it should become a term of daily use and should be introduced into elementary schools. Teachers do not perform their duties honestly or intelligently if they disregard such structural, linguistic, and semantic issues, which, as we have seen, are the central problem of all possible education.

Likewise, we have already seen that the chunk of nature which we call a ‘pencil’ *is not* ‘matter’ nor ‘space’ nor ‘time’, the terms being only *terms.* Is such *el language* structurally appropriate for the purpose of speaking about the world around us ? It seems undeniable that such language is quite out-dated and very unsatisfactory. It introduces structurally an artificial elementalism of a verbal character, in spite of the fact that even the most elementary consideration shows that structurally the opposite is true; namely, that ‘matter’, ‘space’, and ‘time’ can *never* be experimentally divided. The term ‘event’ is precisely the term which does away with this old and vicious elementalism.

All that we deal with in the outside world involves indivisibly ‘matter’, ‘space’, and ‘time’. Using the old language, there cannot be something somewhere at ‘no time’, or something at some ‘time’ and ‘nowhere’ or ‘nothing’ ‘somewhere’ at ‘some time’. Everything which happens must be structurally represented as something, somewhere, at some ‘time’. If the structure of the world happened to be such that ‘nothing’ would happen ‘nowhere’ at ‘no time’, then we should have nothing to talk about, and all we would or could say would deal with our fancies. The four-dimensional language, which describes happenings structurally more nearly as we experience them, is precisely the language of ‘events’. It should be remembered that in daily life we live by four-dimensional event-conditions. That is, the events which interest us are something, somewhere, and some ‘time’. If we want two of our friends to become acquainted with each other, we invite them to our home. The appointment is in three dimensions in ‘space’ (to the left or to the right, forward or backward, up or down), and at a given hour. So we see that our daily life is lived in a four-dimensional space-time manifold, and we begin to appreciate the fact that science has lately caught up with such fundamental structural ‘realities’. It must be noticed that the new four-dimensional space-time *language* does not, or should not, use the *term* ‘matter’ as we used it in the old way. In the new language, the bits of materials we deal with are connected analytically with the ‘curvature’ of this space-time manifold.

The reader should realize that the structurally new language is similar to the structure of our experience, and involves profound methodological and, therefore, psycho-logical, semantic factors. It has entirely different semantic values; and, perhaps, because of this fact, it is an irreversible advance, no matter how details may be altered.

The newtonians, for the most part, overlook the fact that all theories, their own included, are a semantic product of the functioning of the nervous system, and so involve some 'logic' and 'psychology'. In the new theories, a kind of *physical* always appears which ought to be taken care of. We know, for instance, that if we immerse a part of a straight stick in water, the stick appears to be broken, although actually it has not been broken. A photographic camera gives a similar record. So we see that, besides the psycho-logical subjectivity, there is a most important *physical subjectivity*, which is introduced by the use of instruments. The main difficulties in modern science are precisely in the elimination of this physical subjectivity, particularly when we deal with such minute entities that the light waves miss them. In the case of an hypothetical gamma-ray microscope, for instance, the rays would produce what is called a Compton effect,* and so the results of the experiment would be altered by the instrument and procedure.

We ought not to be surprised that the old systems of 'motion' and 'emotion' in science (Newton) and 'philosophy' (Bergson) should result from speculations on the old *A el* language and the introduction of fanciful and fallacious assumptions of an 'infinity' somewhere, and other fancies. The realization of this marks a new semantic epoch in our lives. It is to the credit of these two men that they have summarized these old tendencies in such a masterly way that we are enabled to go beyond them. We shall return to this subject when we analyse the four-dimensional 'world' of Minkowski, and, then, we shall summarize briefly what we now know about 'space', 'time', and 'matter' (see Parts IX and X).

* Compton discovered, in 1923, that the generation of secondary continuous Röntgen radiation by a primary radiation is accomplished by an increase in the wave-length.