LOGIC

PART III

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THE LOGICAL FOUNDATIONS OF SCIENCE

BY

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INTRODUCTION

§ 1. The subjects discussed in Parts I and II come within the scope of what may be called Formal Logic. Here the proposition is taken to be the immediate object of a possible assertion; and a consideration of its nature leads to the conception of the antithesis and connection of substantive with adjective, as disclosed in the analysis of the simplest articulate form of judgment. The function of language and more particularly of names is examined. It is held that the different forms assumed by compound propositions are indicated by various words, not standing for substantival or adjectival constituents, but expressive of the modes in which simple propositions or their constituents are to be connected by constructive thought. Such considerations lead to a preliminary definition and enumeration of logical categories roughly corresponding to (and replacing) the grammatical enumeration of parts of speech.

In the more detailed examination which follows, substantives proper or existents are distinguished from quasi-substantives, adjectives predicable of the former being termed primary and those predicable of the latter secondary. Modality, in its formal aspects, is treated under the more general heading of secondary propositions. Adjectives are divided into transitive adjectives (otherwise relations) and intransitive adjectives, in precise analogy with the grammatical division of verbs; and again into monadic, dyadic, triadic, etc. according to the number of substantive-terms which are entailed

in their employment. A prominent place is given to the distinction and connection, amongst adjectives in general, between adjectival determinables and adjectival determinates. This distinction is utilised in all the further developments of logical theory. The relations between inference and implication, the former of which is essentially epistemic and the latter essentially constitutive are entered into at considerable length. In particular, certain general and fundamental *principles* of inference are laid down and contrasted as formal with the *premisses* of inference which are material.

Inferences and implications are divided into the two species demonstrative and problematic. The term induction has been used, with some hesitation, to include four species—intuitive, summary, demonstrative and problematic. The first three of these are examined in Part II, the fourth being reserved for Part III. Deductive inference or implication is treated in connection with the intuitive foundations of pure logic and pure mathematics; as also with summary induction.

§ 2. It is contended, in agreement with most recent logicians, that Arithmetic and (more generally) Pure Mathematics develops from Pure or Formal Logic: i.e. that the conceptions and axioms underlying the former are none other than those underlying the latter. If any distinction is to be made between Pre-mathematical Logic and Pure Mathematics it is suggested that the latter introduces certain adjectives and relations which in the strictest sense are constant, i.e. represented by words or symbols of which it is essential for the science that the meanings should be understood in one invariable sense; whereas the intelligent apprehension of

pre-mathematical formulae requires that symbols for adjectives and relations in general should be understood merely illustratively to stand indifferently for any actual adjectives that might be substituted for them.

Now, in the transition from pre-mathematical to mathematical logic, the first notions that demand explicit recognition are those of *identity* and (its contrary) *otherness* or diversity. These two relations are applicable to any entities whatsoever coming under any category whatever. Thus if *a* unambiguously denotes any entity whatever and *b* unambiguously denotes any entity whatever, then (so far) the entity denoted by *a* may be identical with and may be other than that denoted by *b*. At this point, the two axioms that identity and otherness are co-alternate and co-disjunct have to be explicitly formulated. Speaking loosely, the relation of identity yields the notion of *one* and that of otherness yields the notion of *two*. More accurately and precisely the conception of *number* is developed from that of a certain sub-division of the genus *relation* termed *one-one*; and *one-one* relations are defined entirely in terms of identity and otherness; i.e. no other notions than these are involved beyond those appertaining to pre-mathematical logic. In this way, the definition, not only of any assigned finite number, but even of infinite number introduces (besides pre-mathematical notions) *identity* and *otherness* alone. In the higher branches of arithmetic other relations, dyadic, triadic, etc., are introduced, especially those which develop from the general notion of *order*; and these are all expressed and defined in terms of words or symbols having a fixed invariable meaning that must be understood by the mathematician as such.

Not only must the mathematician understand the meanings of the constant symbols introduced and defined in the science, but also his intelligent assent is required to be given to certain axioms (or primarily fundamental propositions) expressed in terms of these symbols; and his intelligence must be further exercised in following the demonstrative procedure by which derivative formulae are progressively inferred. He discovers, not only the comparatively unimportant fact that the conclusions are true provided that the originally premised axioms are true, but also the more important fact that the conclusions follow demonstratively from a judicious combination of these axioms and *these alone* —none other being required. The account of symbolism and allied topics in Part II includes references to processes of thought and thus is largely psychological—in this respect differing from the accounts given by professedly formal logicians.

§ 3. Part III opens new ground. Such ontological conceptions as those of substance and causality—even of 'matter' and 'mind'—are explicitly introduced and their significance discussed in detail. In this way, a claim is made that logic should be recognised as a department of philosophy in a higher sense than any warranted by the restriction of its scope to what has been termed formal logic. It is true that inductive logicians have bestowed much care upon the examination of the nature of cause and, less explicitly, of substance. But for the most part they have deliberately excluded any discussion of the philosophical implications attached to these notions; either on the ground that these implications belong to metaphysics or that they

are to be rejected *in toto* as merely bad metaphysics. For example, though much of what Mill has said and Venn has said better about causal and other uniformities has its value, yet it is obvious that their treatment gives us no instruction on the philosophical questions at issue. Moreover, not only the professedly philosophical logicians but, strangely enough, also the humbler inductive logicians have overlooked or devoted insufficient attention to many methodological problems the discussion of which belongs to the logic of the sciences. This constitutes my apology for entering with considerable detail into topics which lie on the borderland between Logic as Methodology and Logic as Philosophy.

The inductive logicians may be said to have presented a philosophical case only on the supposition that they are to be interpreted as having contended for the inutility of such notions as those of causality and substance in the establishment of scientific generalisations. Thus Mill's reduction of the causal relation to invariable and unconditional sequence is naturally interpeted as tantamount to the rejection of the notion of cause in any philosophical sense. And this is certainly the contention of those among later empiricists who have concerned themselves with the problems of scientific induction. In fact, the more modern view expressly held by formal logicians of the present day (who are mostly empiricists of the school of Hume) is that all the principles of induction (with the doubtful exception of probability) are derivable by an extension of the principles of deduction much as Pure Mathematics is a mere extension of Pure Logic. With this view I am in partial agreement, and the discussions of Part III are largely concerned with

the points both of agreement and disagreement between my view and that of the more extreme empiricists.

In examining the logical foundations of science, I have found it impossible to separate the Epistemological (or preferably Epistemic) from the Ontological point of view. The explanation of this impossibility is that, as it appears to me, certain notions—and certain propositions expressible in terms of these notions—must be *postulated*, if science is to be validly established.

By a postulate I understand a proposition that is assertorically and not merely hypothetically entertained; but yet is adopted neither on the ground of intuitive self-evidence nor of inductive confirmation. More positively, a postulate is framed in terms not given in experience, and these terms enter even into the instantial propositions which are problematically universalised by induction. Postulates, in my view, enter even into mere observations of instances which may otherwise be termed judgments of perception. In these judgments the thinker predicates not merely a concomitance of characters presented to him; but, besides concomitance, causality; and, besides presentment, reference to substance.

§ 4. The ontological discussions of Part III are centred upon the recognition of the two concepts, causality and substance. But I have discarded the term 'substance,' for reasons which need no enumeration, in favour of the term 'continuant.' The genus 'substantive proper,' otherwise termed 'existent,' is divided into the two species 'Continuant' and 'Occurrent.' The distinction among substantives between continuants and occurrents plays a similarly prominent part in material

logic as is played in formal logic by the distinction among adjectives between determinables and determinates. But no *analogy* can be drawn between the antithesis or connection in the one case and that in the other. Negatively, it may be said that a continuant is not a mere collection of occurrents just as a determinable is not a mere collection of determinates. Further than this we can only say that a plurality of occurrents is constructed by thought into a unity by virtue of the nexus of causality and a plurality of determinates by virtue of the relation of opponency or incompatibility. No *positive* analogy can be drawn, owing (it would seem) to the ultimately irresolvable antithesis between substantive and adjective.

§ 5. A more detailed summary of the views propounded in Part III on ontological problems may now be given.

In the first place, I have adopted the dualistic position which recognises a fundamental distinction between the psychical and the physical, and attributes reality to both in the same unequivocal sense. Whether or not the view is philosophically tenable, at any rate any examination into the principles of science would seem to be impossible without some such hypothesis as that of dualism. Spinoza's acceptance of two unsynthesised attributes,—thought and extension—illustrates, in more or less veiled guise, the very same fundamental position as that adopted by the dualist. But the view that I wish to put forward is less dualistic than Spinoza's, in that I profess to present the psychical and the physical in some sort of synthesis with one another, and not in mere unreconciled antithesis. What I hold to

be important in the dualistic position is the recognition of two kinds of *agency*—psychical agency and physical agency. Of my views, on this and kindred matters, I do not profess to be able to offer any direct demonstration, nor do I believe that my philosophical opponents can offer any valid refutation. The more detailed exposition of my philosophy must be allowed to be taken as a substitute for strict demonstration.

A continuant is defined to be that which continues to exist throughout some limited or unlimited period of time, during which its inner states or its outer connections with other continuants may be altering or may be continuing unaltered. In the first place, then, the continuant must be contrasted with its states—the possessive pronoun here pointing to a unique species of 'tie' indicated by the preposition *of* to be understood in a specific sense differing from all other senses. There is no relational word (as far as I know) that can be used to express this specific meaning of 'of,' parallel to the relational word *characterising* which expresses the specific meaning of 'of' in such a phrase as "the quality *of* this or that." In fact, the two meanings of the word are continually combined in constructions such as those expressed by the phrase "the quality *of* this or that state *of* this or that continuant." Just as a quality must be attached or referred to this or that state, so a state must be attached or referred to this or that continuant. We may also speak of a property *of* this or that continuant to mean a property *characterising* this or that continuant, so that *property* (in this application) is a species of the genus *adjective*.

Now while we cannot say that a *continuant* occurs,

we *can* say that a *state* occurs; and anything that may be said to occur will be called an 'occurrent.' And I lay it down that any occurrent must be referred to a continuant or to two or more connected continuants. The reference of an occurrent to connected continuants will be entailed when we speak of *transeunt* causality; while the reference of an occurrent to a single continuant will be entailed sometimes in speaking of *immanent* causality and sometimes in speaking of *transeunt* causality.

§ 6. In many applications 'occurrent' and 'event' may be taken as synonyms; but, properly speaking, they must be distinguished. Thus what is called a *single* event is (or may be) resolvable into a plurality of occurrents of different kinds. The resolution of an event into a plurality of occurrents must not be confounded with the partition of an event into a plurality of parts. The parts of an event are themselves events; and these are distinguished from one another by their difference of spatio-temporal location. On the other hand, the occurrents composing an event cannot be distinguished by difference of location, for they must be located within the same spatio-temporal boundaries as the event itself.

The above general account of the distinction between occurrents and events may be considered first in regard to physical and next in regard to psychical events. A physical event has a spatio-temporal extension which is defined by the spatio-temporal boundary within which it falls, which again determines the four-dimensional magnitude of the extension. In order to distinguish between one and another physical event it would seem, therefore, both necessary and sufficient that we should

be able to assign different spatio-temporal boundaries to the two. This holds even of the event-parts of a whole event as distinguished from one another and from the whole; the different event-parts being said to occupy different parts of the extension occupied by the whole event. Now, besides mentally dividing an event into parts, we may also mentally resolve an event into occurrents. The several occurrents which thus compose an event are distinguished, not by the spatio-temporal position which they occupy, but by the different adjectival determinables under which their determinate characters fall. Now all that is here said about physical events and physical occurrents holds also of psychical events and psychical occurrents, except for the fact that spatial reference cannot be applied to the latter and temporal reference only remains. It follows that the extension of a psychical event and the magnitude of its extension are one-dimensional instead of four-dimensional. Hence, whereas difference of position would seem to be necessary and sufficient to mark off one physical event from another, difference of dating is not necessary or sufficient for marking off one psychical event from another. Thus, if one person is suffering tooth-ache contemporaneously with another person's reflecting upon a mathematical problem, we should speak of these as *two* events, although we cannot attribute to either of them spatial extension or boundary and, therefore, cannot attribute to them *different* spatial extensions or boundaries.

This shows that in order mentally to separate one psychical event from another we must postulate, not only a difference of temporal position (if any), but also

different psychical continuants to which the two different psychical events are to be referred. *A priori*, indeed, the same must hold as regards physical events; i.e. two simultaneous events might occupy the same locality, which is tantamount to the possibility that two bodies (physical continuants) should be 'occupying' the same place at the same time. This postulate would be necessitated if we found that two phenomena, not in immediate causal relation, such as pressure and attraction were occurring at the same place and at the same time; just as we are necessitated to postulate two psychical continuants when two psychical events, not in immediate causal relation, occur within the same period of time.

§ 7. In transeunt causality, as so far expounded, we conceive two continuants—which in the first instance are to be physical—in causal connection with one another; in such wise that the alterable 'state' of the one continuant is attributed as effect of its alterable relation with the other. This conception of transitive causality gives significance to the antithesis 'agent-patient.' That continuant whose 'state' is occasioned by its relation with the other continuant is termed (in this connection) patient, and that continuant whose relation to the former occasions the state is termed agent. Logicians who have rejected the antithesis between agent and patient have done so on the ground that every agent is at the same time patient and every patient is at the same time agent. But, even, if this were universally the case, the distinction would remain; since the state of the one continuant is effect of its relation with the other continuant while the concurrent state of the other continuant is effect of its relation with the

former. We can always distinguish between the one cause which occasions *its* effect and the other cause which occasions *its* effect. Hence, I should substitute for Kant's three categories of relation: Continuant and State; Cause and Effect; Agent and Patient.

Several points in the consideration of transeunt and immanent causality must be noted.

(*a*) Processes which are immanent to a whole system of interacting continuants may always be regarded as entailing transeunt causality between the parts of the whole system. This aspect of causality is familiar to the student of Physical Science. Or—to express the same principle in converse form—if we primarily conceive of interaction between parts of a system as exhibiting transeunt causality, we may (without contradiction) express our formulae in terms of causality immanent to the whole. Physics is at first provisionally monadistic, but it becomes increasingly monistic, in the sense that the entire range of physical phenomena come to be systematised as immanent to the whole. This reduction of the whole of physical reality to a self-contained system by no means precludes the exposition of details in terms of transeunt causality.

(*b*) Now, although a monistic form may be given to the system of all physical reality, psychical reality remains essentially pluralistic, and cannot be formulated monistically. In a certain sense, physical reality exhibits the kind of causality that is termed transeunt and no physical causality is strictly immanent. This is because the ultimate constituents of matter—if there are ultimate constituents—have, so to speak, no insides. A physical event must always and can only be described as a

changing or unchanging spatial relation of one thing to another,—the ultimate 'thing' having no inner 'states' which can be said to change or to remain unchanged. Hence, the immanency ascribed to the processes occurring within a mentally isolated material 'body,' is only immanency relative to processes occurring within other mentally isolated material 'bodies.' Nevertheless the conception of immanency cannot be eliminated in the formulation of physical laws; because the effects upon one body due to transeunt action from another are modifications of what *would be happening* within the body were no such transeunt causality in operation. Hence, the analysis of transeunt process always entails reference to immanent process; yet the converse (as it seems) does not universally hold; that is to say, it seems that purely immanent processes occur within the experiences of a single Experient (Psychical Continuant), though perhaps never within the happenings of a single Occupant (Physical Continuant).

§ 8. The more general problem in regard to transeunt and immanent causality relates to the modes in which the two forms operate in conjunction with one another. When any complete event is described in terms both of transeunt and of immanent causality, it would appear that, in transeunt causation, the cause-event and the effect-event are simultaneous; but that, in immanent causation, the cause-event always precedes the effect-event. This view is in direct contradiction to the prevailing view amongst philosophers who profess to attach scientific significance to the antithesis between the transeunt and the immanent. Illustrations in support of my contention will be found in the body of my work,

where the temporal relations between cause and effect are discussed. Where cause precedes effect, as in immanent causality, I hold, in agreement with other philosophers, that there is no temporal gap between the two; they are strictly contiguous or as Dr Broad expresses it *adjoined*. Similarly, in transeunt causality, so far as spatial-relations between the two concerned continuants can be assigned, strict spatial contiguity goes along with temporal co-incidence. The above account must be understood to be preliminary and in a sense provisional; for, on further investigation, it will be seen that the simple principle that I have laid down must be partially modified.

§ 9. The views advanced in Part III on the problem of mutual interaction between 'mind' and 'body' may here be sketched in outline; and it should be said at once that I adopt the common-sense dualistic position and am, therefore, largely concerned with reconciling this position with the claim of science to have succeeded in formulating psychical and physical processes in general but precise terms. The common-sense view expressed briefly is as follows. Certain physical processes occur in accordance with purely physical laws and are unaffected by 'mind'; and similarly certain psychical processes occur in accordance with purely psychical laws and are unaffected by 'body.' Again, there are critical instants when a physical cause occasions a psychical effect which I shall term a *sensation*; and there are critical instants when a psychical cause which I shall term a *volition* occasions a physical effect. Of these last two cases, the former I shall refer to under the heading physico-psychical causality; the latter, under

the heading psychico-physical causality. Since sensations (immediately occasioned by a physical cause) often engender psychical processes terminating in an act of volition which in its turn initiates a physical process; and since this latter sooner or later produces a physical consequent which, at a critical instant, occasions a sensation, the whole system of action and interaction assumes a cyclic form. In such cases, action initiated from either side is followed by reaction initiated from the other. But there is no reason to suppose that the cycle is in all cases completed. On the contrary, some stimuli which initiate modification of sensation are not followed by a consequent volition which initiates modification in the physical world; and some volitions which initiate modification in the physical world are not followed by a consequent stimulus which initiates modification of sensation. Action followed by reaction is probably the exception rather than the rule.

The cyclic processes may be roughly schematised as exhibiting, *alternately*, transeunt and immanent process. The Greek letters ϕ and ψ indicate respectively 'physical' and 'psychical' occurrences, and an arrow stands for 'causing' as also for 'preceding.' Thus:

$$(1) \quad \phi_a \rightarrow \psi_1 \rightarrow \psi_2 \rightarrow \phi_b\,,$$

$$(2) \quad \psi_a \rightarrow \phi_1 \rightarrow \phi_2 \rightarrow \psi_b\,.$$

Here the action $\phi_a \rightarrow \psi_1$ is followed by the reaction $\psi_2 \rightarrow \phi_b$, and the action $\psi_a \rightarrow \phi_1$ is followed by the reaction $\phi_2 \rightarrow \psi_b$. While, moreover, these actions and reactions illustrate *transeunt* causality, the intermediate processes $\psi_1 \rightarrow \psi_2$ and $\phi_1 \rightarrow \phi_2$ I shall speak of as *immanent*.

In case (2), the relation of the originative volition ψ_a to the terminal sensation ψ_b illustrates 'purpose.'

In case (1), the relation of the physical occurrence ϕ_a (which initiates the cycle) to the physical occurrence ϕ_b (which terminates the cycle) raises a general problem which is as yet without any unanimously accepted solution. This problem must be approached from a new side.

The problem next immediately before us is that of psycho-physiological parallelism. The term 'parallelism' is the well-known figurative equivalent for one-one correspondence or one-one correlation. But, unfortunately, it is used with further implications of meaning, two of which are in flat contradiction with one another. In philosophical usage, parallelism is generally understood to *deny* causal relation between the psychical and physiological correspondents; but, in Science, no such denial is implied (except of course by those scientists who reject causality altogether and substitute invariability). Now the grounds for maintaining parallelism in the philosophical sense have nothing whatever in common with those for maintaining parallelism in the scientific sense. In fact, at least as regards neural and sensational processes, most uninstructed persons accept scientific parallelism and would (if it occurred to them) deny philosophical parallelism. They would say that, inasmuch as variations in sensation correspond to variations in neurosis (as they are informed by competent scientists) the former variations are certainly caused by the latter.

§ 10. Here it is to be noted that the scientific assertion of correspondence is one-sided, whenever (as seems inevitable) the notion of causality is superimposed upon that of invariability. Impartial correspondence would assert that, just as the causal antecedents of a sense-

stimulus—which occasions a modification of sense-experience—are purely physical, so the causal antecedents of a volition—which occasions a modification in the physical world—are purely psychical. Scientists, however, mostly appear to maintain that it is a mere illusion to suppose that the processes of desire or feeling and cognition or thought which terminate in a volition are causally operative. They maintain that the really operative causality resides in the neural process which, in accordance with the correspondence theory, accompanies the conative and cognitive experiences. In short, whenever the psychical processes $\psi_1, \psi_2, \psi_3, \ldots$ follow one another in a temporal and invariable order, this is so *because* the physical processes $\phi_1, \phi_2, \phi_3, \ldots$ follow one another in a temporal and invariable order. They, thus, tacitly maintain a one-sided operation of transeunt causality. They assert that the sequence $\phi_1 \rightarrow \phi_2 \rightarrow \phi_3$ constitutes the cause of the sequence $\psi_1 \rightarrow \psi_2 \rightarrow \psi_3$, and this assertion entails that the sequence $\psi_1 \rightarrow \psi_2 \rightarrow \psi_3$ never constitutes the cause of the sequence $\phi_1 \rightarrow \phi_2 \rightarrow \phi_3$. Adapting our previous schematisation to the present problem, the scientists' view would be indicated thus:

$$\begin{array}{ccc} \psi_1 & \rightarrow & \psi_2 \\ \uparrow & & \uparrow \\ \phi_1 & \rightarrow & \phi_2 \end{array}$$

in contrast with

$$\begin{array}{ccc} \psi_1 & \rightarrow & \psi_2 \\ \downarrow & & \downarrow \\ \phi_1 & \rightarrow & \phi_2, \end{array}$$

where the vertical arrows (in both cases) stand for transeunt causality.

Of course, if causality were excluded altogether, so that the vertical arrows stood merely for simultaneity and the horizontal arrows merely for sequence, then there would be no relevant distinction between the two alternative modes of representing the facts. Now, the view of alternate action and reaction is partially expressed by saying that, in some cases ϕ_1 and ϕ_2 respectively cause ψ_1 and ψ_2, while in other cases ψ_1 and ψ_2 respectively cause ϕ_1 and ϕ_2. That is to say in cases where ψ_1, ψ_2, etc. stands for a sequence of sensations then these are related to the sequence of neural processes ϕ_1, ϕ_2, etc. as effect to cause. But in cases where ψ_1, ψ_2, etc. stand for a course of conative and cognitive deliberation, then (if this course is accompanied by any discoverable physiological processes *corresponding* to the course of the psychical processes) ψ_1, ψ_2, etc. are related to ϕ_1, ϕ_2 as cause to effect.

In Part III a still bolder view is put forward: viz. that just as there are countless cases in which physical processes do not immediately occasion any psychical processes whatever, so there are cases in which psychical processes do not immediately occasion any physical process whatever. This view may be termed *impartial dualism*. Or—expressing the same view in metaphorical but familiar language—what is maintained is that man is a genuinely causal agent in reference to which his bodily organism serves directly and materials outside his organism indirectly as *instruments of his will*. On this view, a volition is immanently caused by such purely psychical processes as feeling, desire, knowledge and thought to which there are no neural or physiological correspondents.