K R POPPER IN OBJECTIVE KNOWLEDGE 1973

6. Of Clouds and Clocks

AN APPROACH TO THE PROBLEM OF RATIONALITY AND THE FREEDOM OF MAN

I

MY predecessor who in this hall gave the first Arthur Holly Compton Memorial Lecture a year ago was more fortunate than I. He knew Arthur Compton personally; I never met him.[1]

But I have known of Compton since my student days in the nineteen-twenties, and especially since 1925 when the famous experiment of Compton and Simon[2] refuted the beautiful but short-lived quantum theory of Bohr, Kramers, and Slater.[3] This refutation was one of the decisive events in the history of quantum theory, for from the crisis which it created there emerged the so-called 'new quantum theory'—the theories of Born and Heisenberg, of Schrödinger, and of Dirac.

It was the second time that Compton's experimental tests had played a crucial role in the history of quantum theory. The first time had been, of course, the discovery of the Compton effect, the first independent test (as Compton himself pointed out[4]) of Einstein's theory of light quanta or photons.

Years later, during the Second World War, I found to my surprise and pleasure that Compton was not only a great physicist but also a genuine and courageous philosopher; and further, that his philosophical interests and aims coincided with

[1] When I came to Berkeley early in Feb. 1962 I was eagerly looking forward to meeting Compton. He died before we could meet.

[2] A. H. Compton and A. W. Simon, *Phys. Rev.* **25**, 1925, pp. 309 ff. (See also W. Bothe and H. Geiger, *Zeit. f. Phys.* **26**, 1924, pp. 44 ff., and **32**, 1925, pp. 639 ff.; *Naturwissenschaften*, **13**, 1925, p. 440.)

[3] N. Bohr, H. A. Kramers, and J. C. Slater, *Phil. Mag.* **47**, 1924, pp. 785 ff., and *Zeitschr. f. Phys.*, **24**, 1924, pp. 69 ff. See also A. H. Compton and S. K. Allison, *X-Rays in Theory and Experiment*, 1935; for example, pp. 211–27.

[4] See chapter I, section 19, of Compton and Allison (note 3).

This was the second Arthur Holly Compton Memorial Lecture, presented at Washington University on 21 Apr. 1965.

PART 1

my own on some important points. I found this when, almost by accident, I got hold of Compton's fascinating Terry Lectures which he had published in 1935 in a book entitled *The Freedom of Man*.[5]

You will have noticed that I have incorporated the title of Compton's book, *The Freedom of Man*, into my own title today. I have done so in order to stress the fact that my lecture will be closely connected with this book of Compton's. More precisely, I intend to discuss the same problems which Compton discussed in the first two chapters of this book, and again in the second chapter of another of his books, *The Human Meaning of Science*.[6]

In order to avoid misunderstandings I must stress, however, that my lecture today is not mainly about Compton's books. It is rather an attempt to look afresh at the same ancient philosophical problems with which he grappled in these two books, and an attempt to find a new solution to these ancient problems. The sketchy and very tentative solution I am going to outline here seems to me to fit in well with Compton's main aims, and I hope—indeed I believe—that he would have approved of it.

II

THE central purpose of my lecture is to try to put these ancient problems simply and forcefully before you. But first I must say something about the *clouds and clocks* which appear in the title of my lecture.

My clouds are intended to represent physical systems which, like gases, are highly irregular, disorderly, and more or less unpredictable. I shall assume that we have before us a schema or arrangement in which a very disturbed or disorderly cloud is placed on the left. On the other extreme of our arrangement, on its right, we may place a very reliable pendulum clock, a precision clock, intended to represent physical systems which are regular, orderly, and highly predictable in their behaviour.

[5] A. H. Compton, *The Freedom of Man*, 1935 (third edn., 1939). This book was based mainly on the Terry Foundation Lectures, delivered by Compton at Yale in 1931, and in addition on two other series of lectures given soon after the Terry Lectures.

[6] A. H. Compton, *The Human Meaning of Science*, 1940.

According to what I may call the commonsense view of things, some natural phenomena, such as the weather, or the coming and going of clouds, are hard to predict: we speak of the 'vagaries of the weather'. On the other hand, we speak of 'clockwork precision' if we wish to describe a highly regular and predictable phenomenon.

There are lots of things, natural processes and natural phenomena, which we may place between these two extremes—the clouds on the left, and the clocks on the right. The changing seasons are somewhat unreliable clocks, and may therefore be put somewhere towards the right, though not too far. I suppose we shall easily agree to put animals not too far from the clouds on the left, and plants somewhat nearer to the clocks. Among the animals, a young puppy will have to be placed further to the left than an old dog. Motor cars, too, will find their place somewhere in our arrangement, according to their reliability: a Cadillac, I suppose, is pretty far over to the right, and even more so a Rolls-Royce, which will be quite close to the best of the clocks. Perhaps furthest to the right should be placed the *solar system*.[7]

As a typical and interesting example of a cloud I shall make some use here of a cloud or cluster of small flies or gnats. Like the individual molecules in a gas, the individual gnats which together form a cluster of gnats move in an astonishingly irregular way. It is almost impossible to follow the flight of any one individual gnat, even though each of them may be quite big enough to be clearly visible.

Apart from the fact that the velocities of the gnats do not show a very wide spread, the gnats present us with an excellent picture of the irregular movement of molecules in a gas cloud, or of the minute drops of water in a storm cloud. There are, of course, differences. The cluster does not dissolve or diffuse, but it keeps together fairly well. This is surprising, considering the disorderly character of the movement of the various gnats; but it has its analogue in a sufficiently big gas cloud (such as our atmosphere, or the sun) which is kept together by gravitational forces. In the case of the gnats, their keeping together can be easily explained if we assume that, although they fly quite irregularly in all directions, those that find that they are getting

[7] For the imperfections of the solar system see notes 11 and 16 below.

away from the crowd turn back towards that part which is densest.

This assumption explains how the cluster keeps together even though it has no leader, and no structure—only a random statistical distribution resulting from the fact that each gnat does exactly what he likes, in a lawless or random manner, together with the fact that he does not like to stray too far from his comrades.

I think that a philosophical gnat might claim that the gnat society is a great society or at least a good society, since it is the most egalitarian, free, and democratic society imaginable.

However, as the author of a book on *The Open Society*, I would deny that the gnat society is an open society. For I take it to be one of the characteristics of an open society that it cherishes, apart from a democratic form of government, the freedom of association, and that it protects and even encourages the formation of free sub-societies, each holding different opinions and beliefs. But every reasonable gnat would have to admit that in his society this kind of pluralism is lacking.

I do not intend, however, to discuss today any of the social or political issues connected with the problem of freedom; and I intend to use the cluster of gnats not as an example of a *social* system, but rather as my main illustration of a cloud-like *physical* system, as an example or paradigm of a highly irregular or disordered cloud.

Like many physical, biological, and social systems, the cluster of gnats may be described as a 'whole'. Our conjecture that it is kept together by a kind of attraction which its densest part exerts on individual gnats straying too far from the crowd shows that there is even a kind of action or control which this 'whole' exerts upon its elements or parts. Nevertheless, this 'whole' can be used to dispel the widespread 'holistic' belief that a 'whole' is *always* more than the mere sum of its parts. I do not deny that it may sometimes be so.[8] Yet the cluster of gnats is an example of a whole that is indeed nothing but the sum of its

[8] See section 23 of my book *The Poverty of Historicism* (1957 and later edns.), where I criticize the 'holistic' criterion of a 'whole' (or '*Gestalt*') by showing that this criterion ('a whole is more than the mere sum of its parts') is satisfied even by the favourite holistic examples of non-wholes, such as a 'mere heap' of stones. (Note that I do not deny that there exist wholes; I only object to the superficiality of most 'holistic' theories.)

parts—and in a very precise sense; for not only is it completely described by describing the movements of all the individual gnats, but the movement of the whole is, in this case, precisely the (vectorial) sum of the movements of its constituent members, divided by the number of the members.

An example (in many ways similar) of a biological system or 'whole' which exerts some control over the highly irregular movements of its parts would be a picnicking family—parents with a few children and a dog—roaming the woods for hours, but never straying far from the family car (which acts like a centre of attraction, as it were). This system may be said to be even more cloudy—that is, less regular in the movement of its parts—than our cloud of gnats.

I hope you will now have before you an idea of my two prototypes or paradigms, the clouds on the left and the clocks on the right, and of the way in which we can arrange many kinds of things, and many kinds of systems, between them. I am sure you have caught some vague, general idea of the arrangement, and you need not worry if your idea is still a bit foggy, or cloudy.

III

THE arrangement I have described is, it seems, quite acceptable to common sense; and more recently, in our own time, it has become acceptable even to physical science. It was not so, however, during the preceding 250 years: the Newtonian revolution, one of the greatest revolutions in history, led to the rejection of the commonsense arrangement which I have tried to present to you. For one of the things which almost everybody[9] thought had been established by the Newtonian revolution was the following staggering proposition:

All clouds are clocks—even the most cloudy of clouds.

This proposition, 'All clouds are clocks', may be taken as a brief formulation of the view which I shall call '*physical determinism*'.

The physical determinist who says that all clouds are clocks will also say that our commonsense arrangement, with the clouds on the left and the clocks on the right, is misleading, since

[9] Newton himself was not among those who drew these 'deterministic' consequences from his theory; see notes 11 and 16 below.

everything ought to be placed on the extreme right. He will say that, with all our common sense, we arranged things *not according to their nature, but merely according to our ignorance.* Our arrangement, he will say, reflects merely the fact that we know in some detail how the parts of a clock work, or how the solar system works, while we do not have any knowledge about the *detailed* interaction of the particles that form a gas cloud, or an organism. And he will assert that, once we have obtained this knowledge, we shall find that gas clouds or organisms are as clock-like as our solar system.

Newton's theory did not, of course, tell the physicists that this was so. In fact, it did not treat at all of clouds. It treated especially of planets, whose movements it explained as due to some very simple laws of nature; also of cannon balls, and of the tides. But its immense success in these fields turned the physicists' heads; and surely not without reason.

Before the time of Newton and his predecessor, Kepler, the movements of the planets had escaped many attempts to explain or even to describe them fully. Clearly, they somehow participated in the unvarying general movement of the rigid system of the fixed stars; yet they deviated from the movement of that system almost like single gnats deviating from the general movement of a cluster of gnats. Thus the planets, not unlike living things, appeared to be in a position intermediate between clouds and clocks. Yet the success of Kepler's and even more of Newton's theory showed that those thinkers had been right who had suspected that the planets were in fact perfect clocks. For their movements turned out to be precisely predictable with the help of Newton's theory; predictable in all those details which had previously baffled the astronomers by their apparent irregularity.

Newton's theory was the first really successful scientific theory in human history; and it was tremendously successful. Here was real knowledge; knowledge beyond the wildest dreams of even the boldest minds. Here was a theory which explained precisely not only the movements of *all* the stars in their course, but also, just as precisely, the movements of bodies on earth, such as falling apples, or projectiles, or pendulum clocks. And it even explained the tides.

All open-minded men—all those who were eager to learn, and who took an interest in the growth of knowledge—were converted to the new theory. Most openminded men, and especially most scientists, thought that in the end it would explain everything, including not only electricity and magnetism, but also clouds, and even living organisms. Thus physical determinism—the doctrine that all clouds are clocks—became the ruling faith among enlightened men; and everybody who did not embrace this new faith was held to be an obscurantist or a reactionary.[10]

IV

AMONG the few dissenters[11] was Charles Sanders Peirce, the great American mathematician and physicist and, I believe, one of the greatest philosophers of all time. He did not question Newton's theory; yet as early as 1892 he showed that this theory, even if true, does not give us any valid reason to believe that clouds are perfect clocks. Though in common with all other physicists of his time he believed that the world was a clock that worked according to Newtonian laws, he rejected the belief that this clock, or any other, was *perfect*, down to the smallest detail. He pointed out that at any rate we could not possibly claim to know, from experience, of anything like a perfect clock, or of anything even faintly approaching that absolute perfection which physical determinism assumed. I may perhaps quote one of Peirce's brilliant comments: '. . . one who is behind the scenes' (Peirce speaks here as an experimentalist) '. . . knows that the most refined comparisons [even] of masses [and] lengths, . . . far surpassing in precision all other [physical] measurements, . . . fall behind the accuracy of bank accounts, and that the . . . determinations of physical constants . . . are about on a par with

[10] The conviction that determinism forms an essential part of any rational or scientific attitude was generally accepted, even by some of the leading opponents of 'materialism' (such as Spinoza, Leibniz, Kant, and Schopenhauer). A similar dogma which formed part of the rationalist tradition was that all knowledge begins with *observation* and proceeds from there by induction. Cp. my remarks on these two dogmas of rationalism in my book *Conjectures and Refutations*, 1963, 1965, 1969, 1972, pp. 122 f.

[11] Newton himself may be counted among the few dissenters, for he regarded even the solar system as *imperfect*, and consequently as likely to perish. Because of these views he was accused of impiety, of 'casting a reflection upon the wisdom of the author of nature' (as Henry Pemberton reports in his *A View of Sir Isaac Newton's Philosophy*, 1728, p. 180).

an upholsterer's measurements of carpets and curtains . . .'.[12] From this Peirce concluded that we were free to conjecture that there was a certain *looseness or imperfection* in all clocks, and that this allowed an *element of chance* to enter. Thus Peirce conjectured that the world was not only ruled by the *strict Newtonian laws*, but that it was also at the same time ruled by *laws of chance*, or of randomness, or of disorder: by laws of statistical *probability*. This made the world an interlocking system of clouds and clocks, so that even the best clock would, *in its molecular structure*, show some degree of cloudiness. So far as I know Peirce was the first post-Newtonian physicist and philosopher who thus dared to adopt the view that to some degree *all clocks are clouds*; or in other words, that *only clouds exist*, though clouds of very different degrees of cloudiness.

Peirce supported this view by pointing out, no doubt correctly, that all physical bodies, even the jewels in a watch, were subject to molecular heat motion,[13] a motion similar to that of the molecules of a gas, or of the individual gnats in a cluster of gnats.

These views of Peirce's were received by his contemporaries with little interest. Apparently only one philosopher noticed them; and he attacked them.[14] Physicists seem to have ignored

[12] *Collected Papers of Charles Sanders Peirce*, **6**, 1935, 6.44, p. 35. There may of course have been other physicists who developed similar views, but apart from Newton and Peirce I know of only one: Professor Franz Exner of Vienna. Schrödinger, who was his pupil, wrote about Exner's views in his book *Science, Theory and Man*, 1957, pp. 71, 133, 142 f. (This book was previously published under the title *Science and the Human Temperament*, 1935, and Compton referred to it in *The Freedom of Man*, p. 29.) Cp. also note 25 below.

[13] C. S. Peirce, op. cit., **6**, 6. 47, p. 37 (first published 1892). The passage, though brief, is most interesting because it anticipates (note the remark on fluctuations in explosive mixtures) some of the discussion of macro-effects which result from the amplification of Heisenberg indeterminacies. This discussion begins, it appears, with a paper by Ralph Lillie, *Science*, **46**, 1927, pp. 139 ff., to which Compton refers in *The Freedom of Man*, p. 50. It plays a considerable part in Compton's book, pp. 48 ff. (Note that Compton delivered the Terry Lectures in 1931.) Compton, op. cit., note 3, pp. 51 f., contains a very interesting quantitative comparison of chance effects due to molecular heat motion (the indeterminacy Peirce had in mind) and Heisenberg indeterminacy. The discussion was carried on by Bohr, Pascual Jordan, Fritz Medicus, Ludwig von Bertalanffy, and many others; more recently especially also by Walter Elsasser, *The Physical Foundations of Biology*, 1958.

[14] I am alluding to Paul Carus, *The Monist*, **2**, 1892, pp. 560 ff., and **3**, 1892, pp. 68 ff.; Peirce replied in *The Monist*, **3**, 1893, pp. 526 ff. (see his *Collected Papers*, **6**, Appendix A, pp. 390 ff.).

them; and even today most physicists believe that if we had to accept the classical mechanics of Newton as true, we should be compelled to accept physical determinism, and with it the proposition that all clouds are clocks. It was only with the downfall of classical physics and with the rise of the new quantum theory that physicists were prepared to abandon physical determinism.

Now the tables were turned. Indeterminism, which up to 1927 had been equated with obscurantism, became the ruling fashion; and some great scientists, such as Max Planck, Erwin Schrödinger, and Albert Einstein, who hesitated to abandon determinism, were considered old fogies,[15] although they had been in the forefront of the development of quantum theory. I myself once heard a brilliant young physicist describe Einstein, who was then still alive and hard at work, as 'antediluvian'. The deluge that was supposed to have swept Einstein away was the new quantum theory, which had risen during the years from 1925 to 1927, and to whose advent at most seven people had made contributions comparable to those of Einstein.

V

PERHAPS I may stop here for a moment to state my own view of the situation, and of scientific fashions. I believe that Peirce

[15] The sudden and complete transformation of the problem-situation may be gauged by the fact that to many of us old fogies it does not really seem so very long ago that empiricist philosophers (see for example Moritz Schlick, *Allgemeine Erkenntnislehre*, second edn., 1925, p. 277) were physical determinists, while nowadays physical determinism is being dismissed by P. H. Nowell-Smith, a gifted and spirited defender of Schlick's, as an '*eighteenth-century bogey*' (*Mind*, 63, 1954, p. 331; see also note 37 below). Time marches on and no doubt it will, in time, solve all our problems, bogies or non-bogies. Yet oddly enough we old fogies seem to remember the days of Planck, Einstein, and Schlick, and have much trouble in trying to convince our puzzled and muddled minds that these great determinist thinkers produced their bogies in the eighteenth century, together with Laplace who produced the most famous bogy of all (the 'super-human intelligence' of his *Essay* of 1819, often called 'Laplace's demon'; cp. Compton, *The Freedom of Man*, pp. 5 f., and *The Human Meaning of Science*, p. 34, and Alexander, quoted in note 35, below). Yet a still greater effort might perhaps recall, even to our failing memories, a similar eighteenth-century bogy produced by a certain Carus (not the nineteenth-century thinker P. Carus referred to in note 14 but T. L. Carus, who wrote *Lucretius de rerum naturae*, ii. 251–60, quoted by Compton in *The Freedom of Man*, p. 1).

was right in holding that all clocks are clouds, to some considerable degree—even the most precise of clocks. This, I think, is a most important inversion of the mistaken determinist view that all clouds are clocks. I further believe that Peirce was right in holding that this view was compatible with the classical physics of Newton.[16] I believe that this view is even more clearly compatible with Einstein's (special) relativity theory, and it is still more clearly compatible with the new quantum theory. In other words, I am an indeterminist—like Peirce, Compton, and most other contemporary physicists; and I believe, with most of them, that Einstein was mistaken in trying to hold fast to determinism. (I may perhaps say that I discussed this matter with him, and that I did not find him adamant.) But I also believe that those modern physicists were badly mistaken who pooh-poohed as antediluvian Einstein's criticism of the quantum theory. Nobody can fail to admire the quantum theory, and Einstein did so wholeheartedly; but his criticism of the fashionable interpretation of the theory—the Copenhagen interpretation—like the criticisms offered by de Broglie, Schrödinger, Bohm, Vigier, and more recently by Landé, have been too lightly brushed aside by most physicists.[17] There are fashions in science, and some scientists climb on the band wagon almost as readily as do some painters and musicians. But although fashions and bandwagons may attract the weak, they should be resisted rather

[16] I developed this view in 1950 in a paper 'Indeterminism in Quantum Physics and in Classical Physics', *British Journal for the Philosophy of Science*, 1, 1950, No. 2, pp. 117–33, and No. 3, pp. 173–95. When writing this paper I knew nothing, unfortunately, of Peirce's views (see notes 12 and 13). I may perhaps mention here that I have taken the idea of opposing *clouds* and *clocks* from this earlier paper of mine. Since 1950, when my paper was published, the discussion of indeterminist elements in classical physics has gathered momentum. See Leon Brillouin, *Scientific Uncertainty and Information*, 1964 (a book with which I am by no means in full agreement), and the references to the literature there given, especially on pp. 38, 105, 127, 151 f. To these references might be added in particular Jacques Hadamard's great paper concerning geodetic lines on 'horned' surfaces of negative curvature, *Journal de mathématiques pures et appliquées*, 5th series 4, 1898, pp. 27 ff.

[17] See also my book *The Logic of Scientific Discovery*, especially the new Appendix *xi; also chapter ix of this book which contains criticism that is valid in the main, though, in view of Einstein's criticism in Appendix *xii, I had to withdraw the thought experiment (of 1934) described in section 77. This experiment can be replaced, however, by the famous thought experiment of Einstein, Podolsky, and Rosen, discussed there in Appendix *xi and *xii. See also my paper 'The Propensity Interpretation of the Calculus of Probability, and the Quantum Theory', in *Observation and Interpretation*, ed. by S. Körner, 1957, pp. 65–70, and 83–9.

than encouraged;[18] and criticism like Einstein's is always valuable: one can always learn something from it.

VI

ARTHUR HOLLY COMPTON was among the first who welcomed the new quantum theory, and Heisenberg's new physical indeterminism of 1927. Compton invited Heisenberg to Chicago for a course of lectures which Heisenberg delivered in the spring of 1929. This course was Heisenberg's first full exposition of his theory, and his lectures were published as his first book a year later by the University of Chicago Press, with a preface by Arthur Compton.[19] In this preface Compton welcomed the new theory to whose advent his experiments had contributed by refuting its immediate predecessor;[20] yet he also sounded a note of warning. Compton's warning anticipated some very similar warnings by Einstein, who always insisted that we should not consider the new quantum theory—'this chapter of the history of physics', as Compton called it generously and wisely—as being 'complete'.[21] And although this view was rejected by Bohr, we should remember the fact that the new theory failed, for example, to give even a hint of the neutron, discovered by Chadwick about a year later, which was to become the first of a long series of new elementary particles whose existence had

18 The last sentence is meant as a criticism of some of the views contained in Thomas S. Kuhn's interesting and stimulating book *The Structure of Scientific Revolutions*, 1963.

19 See Werner Heisenberg, *The Physical Principles of the Quantum Theory*, 1930.

20 I am alluding to Compton's refutation of the theory of Bohr, Kramers, and Slater, see note 3 above; see also Compton's own allusion in *The Freedom of Man*, p. 7 (last sentence), and *The Human Meaning of Science*, p. 36.

21 Cp. Compton's Preface in Heisenberg, op. cit., pp. iii ff.; also his remarks on the *incompleteness* of quantum mechanics in *The Freedom of Man*, p. 45 (with a reference to Einstein) and in *The Human Meaning of Science*, p. 42. Compton approved of the incompleteness of quantum mechanics while Einstein saw in it a weakness of the theory. Replying to Einstein, Niels Bohr asserted (like J. von Neumann before him) that the theory was *complete* (perhaps in another sense of the term). See for example A. Einstein, B. Podolsky, and N. Rosen, *Physical Review*, **42**, 1935, pp. 777–80; and Bohr's reply in **48**, 1935, pp. 696 ff.; also A. Einstein, *Dialectica*, **2**, 1948, pp. 320–4, and Bohr, pp. 312–19 of the same volume; further, the discussion between Einstein and Niels Bohr in P. A. Schilpp (ed.), *Albert Einstein: Philosopher-Scientist*, 1949, pp. 201–41, and especially 668–74, and a letter of Einstein's, published in my book, *The Logic of Scientific Discovery*, pp. 457–64; see also pp. 445–56.

not been foreseen by the new quantum theory (even though it is true that the existence of the positron could have been derived from the theory of Dirac).[22]

In the same year, 1931, in his Terry Foundation Lectures,[5] Compton became one of the first to examine the human and, more generally, the biological[23] implications of the new indeterminism in physics. And now it became clear why he had welcomed the new theory so enthusiastically: it solved for him not only problems of physics but also biological and philosophical problems, and among the latter especially problems connected with ethics.

VII

To show this, I shall now quote the striking opening passage of Compton's *The Freedom of Man*:

> The fundamental question of morality, a vital problem in religion, and a subject of active investigation in science: Is man a free agent?
>
> If . . . the atoms of our bodies follow physical laws as immutable as the motions of the planets, why try? What difference can it make how great the effort if our actions are already predetermined by mechanical laws . . . ?[24]

Compton describes here what I shall call '*the nightmare of the physical determinist*'. A deterministic physical clockwork mechanism is, above all, completely self-contained: in the perfect deterministic physical world there is simply no room for any outside intervention. Everything that happens in such a world is physically predetermined, including all our movements and therefore all our actions. Thus all our thoughts, feelings, and efforts can have no practical influence upon what happens in the physical world: they are, if not mere illusions, at best superfluous by-products ('epiphenomena') of physical events.

In this way, the daydream of the Newtonian physicist who hoped to prove all clouds to be clocks had threatened to turn into a nightmare; and the attempt to ignore this had led to

22 See the history of its discovery as told by N. R. Hanson, *The Concept of the Positron*, 1963, chapter ix.

23 See especially the passages on 'emergent evolution' in *The Freedom of Man*, pp. 90 ff.; cp. *The Human Meaning of Science*, p. 73.

24 Cp. *The Freedom of Man*, p. 1.

something like an intellectual split personality. Compton, I think, was grateful to the new quantum theory for rescuing him from this difficult intellectual situation. Thus he writes, in *The Freedom of Man*: 'The physicist has rarely . . . bothered himself with the fact that if . . . completely deterministic . . . laws . . . apply to man's actions, he is himself an automaton.'[25] And in *The Human Meaning of Science* he expresses his relief:

> In my own thinking on this vital subject I am thus in a much more satisfied state of mind than I could have been at any earlier stage of science. If the statements of the laws of physics were assumed correct, one would have had to suppose (as did most philosophers) that the feeling of freedom is illusory, or if [free] choice were considered effective, that the statements of the laws of physics were . . . unreliable. The dilemma has been an uncomfortable one . . .[26]

Later in the same book Compton sums up the situation crisply in the words: '. . . it is no longer justifiable to use physical law as evidence against human freedom'.[27]

These quotations from Compton show clearly that before Heisenberg he had been harassed by what I have here called the nightmare of the physical determinist, and that he had tried to escape from this nightmare by adopting something like an intellectual split personality. Or as he himself puts it: 'We [physicists] have preferred merely to pay no attention to the difficulties . . .'[28] Compton welcomed the new theory which rescued him from all this.

I believe that the only form of the problem of determinism which is worth discussing seriously is exactly that problem which worried Compton: the problem which arises from a physical theory which describes the world as a *physically complete* or a

[25] Cp. *The Freedom of Man*, pp. 26 f.; see also pp. 27 f. (the last paragraph beginning on p. 27). I may perhaps remind the reader that my views differ a little from the quoted passage because like Peirce I think it logically possible that the *laws* of a system be Newtonian (and so *prima facie* deterministic) and the system nevertheless indeterministic, because the system to which the laws apply may be intrinsically unprecise, in the sense, for example, that there is no point in saying that its co-ordinates, or velocities, are rational (as opposed to irrational) numbers. The following remark (see Schrödinger, op. cit., p. 143) is also very relevant: '. . . the energy-momentum theorem provides us with only *four* equations, thus leaving the elementary process to a great extent undetermined, even if it complies with them.' See also note 16.

[26] Cp. *The Human Meaning of Science*, p. ix.

[27] Ibid., p. 42.

[28] Cp. *The Freedom of Man*, p. 27.

physically closed system.[29] By a physically closed system I mean a set or system of physical entities, such as atoms or elementary particles or physical forces or fields of forces, which interact with each other—and *only* with each other—in accordance with definite laws of interaction that do not leave any room for interaction with, or interference by, anything outside that closed set or system of physical entities. It is this 'closure' of the system that creates the deterministic nightmare.[30]

VIII

I SHOULD like to digress here for a minute in order to contrast the problem of physical determinism, which I consider to be of fundamental importance, with the far from serious problem which many philosophers and psychologists, following Hume, have substituted for it.

Hume interpreted determinism (which he called 'the doctrine of necessity', or 'the doctrine of constant conjunction') as the doctrine that 'like causes always produce like effects' and that 'like effects necessarily follow from like causes'.[31] Concerning human actions and volitions he held, more particularly, that 'a spectator can commonly infer our actions from our motives and character; and even where he cannot, he concludes in

[29] Assume that our physical world is a *physically closed* system containing chance elements. Obviously it would not be deterministic; yet purposes, ideas, hopes, and wishes could not in such a world have any influence on physical events; assuming that they exist, they would be completely redundant: they would be what are called 'epiphenomena'. (Note that a deterministic physical system will be closed, but that a closed system may be indeterministic. Thus 'indeterminism is not enough', as will be explained in section x, below; see also note 40.)

[30] Kant suffered deeply from this nightmare and failed in his attempts to escape from it; see Compton's excellent statement on 'Kant's avenue of escape' in *The Freedom of Man*, pp. 67 f. (In line 2 on p. 68 the words '*of Pure Reason*' should be deleted.) I may perhaps mention here that I do not agree with everything Compton has to say in the field of the philosophy of science. Examples of views I do not share are: Compton's approval of Heisenberg's positivism or phenomenalism (*The Freedom of Man*, p. 31), and certain remarks (in op. cit., note 7 on p. 20) which Compton credits to Carl Eckart: although Newton himself was, it seems, not a determinist (cp. note 11), I do not think that the fairly precise idea of *physical determinism* should be discussed in terms of some vague 'law of causality'; nor do I agree that Newton was a phenomenalist in a sense similar to that in which Heisenberg may be said to have been a phenomenalist (or positivist) in the nineteen-thirties.

[31] David Hume, *A Treatise of Human Nature*, 1739 (ed. L. A. Selby-Bigge, 1888 and reprints), p. 174; see also, for example, pp. 173 and 87.

general, that he might, were he perfectly acquainted with every circumstance of our situation and temper, and the most secret springs of our . . . disposition. Now this is the very essence of necessity . . .'.[32] Hume's successors put it thus: our actions, or our volitions, or our tastes, or our preferences, are *psychologically* 'caused' by preceding experiences ('motives'), and ultimately by our heredity and environment.

But this doctrine which we may call *philosophical* or *psychological* determinism is not only a very different affair from *physical* determinism, but it is also one which a physical determinist who understands this matter at all can hardly take seriously. For the thesis of philosophical determinism, that 'Like effects have like causes' or that 'Every event has a cause', is so vague that it is perfectly compatible with physical *in*determinism.

Indeterminism—or more precisely, physical indeterminism—is merely the doctrine that *not all* events in the physical world are predetermined with absolute precision, in all their infinitesimal details. Apart from this, it is compatible with practically any degree of regularity you like, and it does not, therefore, entail the view that there are 'events without causes'; simply because the terms 'event' and 'cause' are vague enough to make the doctrine that every event has a cause compatible with physical indeterminism. While physical determinism demands complete and infinitely precise physical predetermination and the absence of *any* exception whatever, physical indeterminism asserts no more than that determinism is false, and that there are *at least some* exceptions, here or there, to precise predetermination.

Thus even the formula 'Every observable or measurable *physical* event has an observable or measurable *physical* cause' is still compatible with physical indeterminism, simply because no measurement can be infinitely precise: for the salient point about physical determinism is that, based on Newton's dynamics, it asserts the existence of a world of absolute mathematical precision. And although in so doing it goes beyond the realm of possible observation (as was seen by Peirce), it nevertheless is testable, in principle, with any desired degree of precision; and it actually withstood surprisingly precise tests.

By contrast, the formula 'Every event has a cause' says nothing about precision; and if, more especially, we look at the laws of psychology, then there is not even a suggestion of precision. This holds for a 'behaviourist' psychology as much as for an 'introspective' or 'mentalist' one. In the case of a mentalist psychology this is obvious. But even a behaviourist may *at the very best* predict that, under given conditions, a rat will take twenty to twenty-two seconds to run a maze: he will have no idea how, by specifying more and more precise experimental conditions, he could make predictions which become more and more precise—and, *in principle, precise without limit.* This is so because behaviourist 'laws' are not, like those of Newtonian physics, differential equations, and because every attempt to introduce such differential equations would lead beyond behaviourism into physiology, and thus ultimately into physics; so it would lead us back to the problem of *physical determinism.*

As noted by Laplace, physical determinism implies that every physical event in the distant future (or in the distant past) is predictable (or retrodictable) with any desired degree of precision, provided we have sufficient knowledge about the present state of the physical world. The thesis of a philosophical (or psychological) determinism of Hume's type, on the other hand, asserts even in its strongest interpretation no more than that any *observable* difference between two events is related by some as yet perhaps unknown law to some difference—an observable difference perhaps—in the preceding state of the world; obviously a very much weaker assertion, and incidentally one which we could continue to uphold even if most of our experiments, performed under conditions which are, *in appearance*, 'entirely equal', should yield different results. This was stated very clearly by Hume himself. 'Even when these contrary experiments are entirely equal', he writes, 'we remove not the notion of causes and necessity, but . . . conclude, that the [apparent] chance . . . lies only in . . . our imperfect knowledge, not in the things themselves, which are in every case equally necessary [i.e., determined], tho' to appearance not equally constant or certain.'[33]

This is why a Humean philosophical determinism and, more

[32] Hume, op. cit., pp. 408 f.

[33] Hume, op. cit., pp. 403 f. It is interesting to compare this with pp. 404 f. (where Hume says 'I define necessity two ways') and with his ascription to 'matter' of 'that intelligible quality, call it necessity or not' which, as he says, everybody 'must allow to belong to the will' (or 'to the actions of the mind'). In other words, Hume tries here to apply his doctrine of custom or habit, and his association psychology, to 'matter'; that is, to physics.

especially, a psychological determinism, lack the sting of physical determinism. For in Newtonian physics things really looked as if any apparent looseness in a system was in fact merely due to our ignorance, so that, should we be fully informed about the system, any appearance of looseness would disappear. Psychology, on the other hand, never had this character.

Physical determinism, we might say in retrospect, was a daydream of omniscience which seemed to become more real with every advance in physics until it became an apparently inescapable nightmare. But the corresponding daydreams of the psychologists were never more than castles in the air: they were Utopian dreams of attaining equality with physics, its mathematical methods, and its powerful applications; and perhaps even of attaining superiority, by moulding men and societies. (While these totalitarian dreams are not serious from a scientific point of view, they are very dangerous politically;[34] but since I have dealt with these dangers elsewhere I do not propose to discuss the problem here.)

IX

I HAVE called physical determinism a nightmare. It is a nightmare because it asserts that the whole world with everything in it is a huge automaton, and that we are nothing but little cogwheels, or at best sub-automata, within it.

It thus destroys, in particular, the idea of creativity. It reduces to a complete illusion the idea that in preparing this lecture I have used my brain to create *something new*. There was no more in it, according to physical determinism, than that certain parts of my body put down black marks on white paper: any physicist with sufficient detailed information could have written my lecture by the simple method of predicting the precise places on which the physical system consisting of my body (including my brain, of course, and my fingers) and my pen would put down those black marks.

[34] See especially B. F. Skinner, *Walden Two*, 1948, a charming and benevolent but utterly naïve Utopian dream of omnipotence (see especially pp. 246–50; also 214 f.). Aldous Huxley, *Brave New World*, 1932 (see also *Brave New World Revisited*, 1959), and George Orwell, *1984*, 1948, are well-known antidotes. I have criticized some of these Utopian and authoritarian ideas in *The Open Society and Its Enemies*, 1945, fourth edn., 1962, and in *The Poverty of Historicism*, e.g., p. 91. (See in both books especially my criticism of the so-called 'sociology of knowledge'.)

Or to use a more impressive example: if physical determinism is right, then a physicist who is completely deaf and who has never heard any music could write all the symphonies and concertos written by Mozart or Beethoven, by the simple method of studying the precise physical states of their bodies and predicting where they would put down black marks on their lined paper. And our deaf physicist could do even more: by studying Mozart's or Beethoven's bodies with sufficient care he could write scores which were never actually written by Mozart or Beethoven, but which they would have written had certain external circumstances of their lives been different: if they had eaten lamb, say, instead of chicken, or drunk tea instead of coffee.

All this could be done by our deaf physicist if supplied with a sufficient knowledge of purely physical conditions. There would be no need for him to know anything about the theory of music—though he might be able to predict what answers Mozart or Beethoven would have written down under examination conditions if presented with questions on the theory of counterpoint.

I believe that all this is absurd;[35] and its absurdity becomes even more obvious, I think, when we apply this method of physical prediction to a determinist.

For according to determinism, any theories—such as, say, determinism—are held because of a certain physical structure of the holder (perhaps of his brain). Accordingly we are deceiving ourselves (and are physically so determined as to deceive ourselves) whenever we believe that there are such things as arguments or reasons which make us accept determinism. Or in

[35] My deaf physicist is of course closely similar to Laplace's demon (see note 15); and I believe that his achievements are absurd, simply because non-physical aspects (aims, purposes, traditions, tastes, ingenuity) play a role in the development of the physical world; or in other words, I believe in *interactionism* (see notes 43 and 62). Samuel Alexander, *Space, Time and Deity*, 1920, vol. ii, p. 328, says of what he calls the 'Laplacean calculator': 'Except in the limited sense described, the hypothesis of the calculator is absurd.' Yet the 'limited sense' *includes* the prediction of *all* purely physical events, and would thus *include* the prediction of the position of all the black marks written by Mozart and Beethoven. It *excludes* only the prediction of mental experience (an exclusion that corresponds closely to my assumption of the physicist's deafness). Thus what I regard as absurd, Alexander is prepared to admit. (I may perhaps say here that I think it preferable to discuss the problem of freedom in connection with the creation of music or of new scientific theories or technical inventions, rather than with ethics, and ethical responsibility.)

other words, physical determinism is a theory which, if it is true, is not arguable, since it must explain all our reactions, including what appear to us as beliefs based on arguments, as due to *purely physical conditions*. Purely physical conditions, including our physical environment, make us say or accept whatever we say or accept; and a well-trained physicist who does not know any French, and who has never heard of determinism, would be able to predict what a French determinist would say in a French discussion on determinism; and of course also what his indeterminist opponent would say. But this means that if we believe that we have accepted a theory like determinism because we were swayed by the logical force of certain arguments, then we are deceiving ourselves, according to physical determinism; or more precisely, we are in a physical condition which determines us to deceive ourselves.

Hume saw much of this, even though it appears that he did not quite see what it meant for his own arguments; for he confined himself to comparing the determinism of '*our judgements*' with that of '*our actions*', saying that '*we have no more liberty in the one than in the other*'.[36]

Considerations such as these may perhaps be the reason why there are so many philosophers who refuse to take the problem of physical determinism seriously and dismiss it as a 'bogy'.[37] Yet the doctrine that *man is a machine* was argued most forcefully and seriously in 1751, long before the theory of evolution became generally accepted, by de Lamettrie; and the theory of evolution gave the problem an even sharper edge, by suggesting that there may be no clear distinction between living matter and dead matter.[38] And in spite of the victory of the new quantum theory, and the conversion of so many physicists to indeterminism, de Lamettrie's doctrine that man is a machine has today perhaps more defenders than ever before among physicists, biologists, and philosophers; especially in the form of the thesis that man is a computer.[39]

[36] Humes, op. cit., p. 609 (the italics are mine).

[37] See note 15, above, and Gilbert Ryle, *The Concept of Mind*, 1949, pp. 76 ff. ('The Bogy of Mechanism').

[38] Cp. N. W. Pirie, 'The Meaninglessness of the Terms Life and Living', *Perspectives in Biochemistry*, 1937 (ed. J. Needham and D. E. Green), pp. 11 ff.

[39] See for example A. M. Turing, 'Computing Machinery and Intelligence', *Mind*, 59, 1950, pp. 433-60. Turing asserted that men and computers are in principle indistinguishable by their observable (behavioural) performance, and challenged his opponents to *specify* some observable behaviour or achievement of man which a computer would in principle be unable to achieve. But this challenge is an intellectual trap: by *specifying* a kind of behaviour we would lay down a specification for building a computer. Moreover, we use, and build, computers because they can do many things which we cannot do; just as I use a pen or pencil when I wish to tot up a sum I cannot do in my head. 'My pencil is more intelligent than I', Einstein used to say. But this does not establish that he is indistinguishable from his pencil. (Cp. the final paragraphs, p. 195, of my paper on Indeterminism, referred to in note 16 above, and chapter 12, section 5, of my book *Conjectures and Refutations*.)

For if we accept a theory of evolution (such as Darwin's) then even if we remain sceptical about the theory that life emerged from inorganic matter we can hardly deny that there must have been a time when abstract and non-physical entities, such as reasons and arguments and scientific knowledge, and abstract rules, such as rules for building railways or bulldozers or sputniks or, say, rules of grammar or of counterpoint, did not exist, or at any rate had no effect upon the physical universe. It is difficult to understand how the physical universe could produce abstract entities such as rules, and then could come under the influence of these rules, so that these rules in their turn could exert very palpable effects upon the physical universe.

There is, however, at least one perhaps somewhat evasive but at any rate easy way out of this difficulty. We can simply deny that these abstract entities exist and that they can influence the physical universe. And we can assert that what do exist are our brains, and that these are machines like computers; that the allegedly abstract rules are physical entities, exactly like the concrete physical punch-cards by which we 'programme' our computers; and that the existence of anything non-physical is just 'an illusion', perhaps, and at any rate unimportant, since everything would go on as it does even if there were no such illusions.

According to this way out, we need not worry about the 'mental' status of these illusions. They may be universal properties of all things: the stone which I throw may have the illusion that it jumps, just as I have the illusion that I throw it; and my pen, or my computer, may have the illusion that it works because of its interest in the problems which it thinks that it is solving—and which I think that I am solving—while in fact there is nothing of any significance going on except purely physical interactions.

You may see from all this that the problem of physical determinism which worried Compton is indeed a serious problem. It is not just a philosophical puzzle, but it affects at least physicists, biologists, behaviourists, psychologists, and computer engineers.

Admittedly, quite a few philosophers have tried to show (following Hume or Schlick) that it is merely a verbal puzzle, a puzzle about the use of the word 'freedom'. But these philosophers have hardly seen the difference between the problem of physical determinism and that of philosophical determinism; and they are either determinists like Hume, which explains why for them 'freedom' is 'just a word', or they have never had that close contact with the physical sciences or with computer engineering which would have impressed upon them that we are faced with more than a merely verbal puzzle.

X

LIKE Compton I am among those who take the problem of physical determinism seriously, and like Compton I do not believe that we are mere computing machines (though I readily admit that we can learn a great deal from computing machines —even about ourselves). Thus, like Compton, I am a *physical indeterminist*: physical indeterminism, I believe, is a necessary prerequisite for any solution of our problem. We have to be indeterminists; yet I shall try to show that indeterminism is not enough.

With this statement, *indeterminism is not enough*, I have arrived, not merely at a new point, but at the very heart of my problem.

The problem may be explained as follows.

If determinism is true, then the whole world is a perfectly running flawless clock, including all clouds, all organisms, all animals, and all men. If, on the other hand, Peirce's or Heisenberg's or some other form of indeterminism is true, then sheer *chance* plays a major role in our physical world. *But is chance really more satisfactory than determinism?*

The question is well known. Determinists like Schlick have put it in this way: '. . . freedom of action, responsibility, and mental sanity, cannot reach beyond the realm of causality: they stop where chance begins. . . . a higher degree of randomness . . . [simply means] a higher degree of irresponsibility.'[40]

I may perhaps put this idea of Schlick's in terms of an example I have used before: to say that the black marks made on white paper which I produced in preparation for this lecture were just the result of *chance* is hardly more satisfactory than to say that they were physically predetermined. In fact, it is even less satisfactory. For some people may perhaps be quite ready to believe that the text of my lecture can be in principle completely explained by my physical heredity, and my physical environment, including my upbringing, the books I have been reading, and the talks I have listened to; but hardly anybody will believe that what I am reading to you is the result of nothing but chance —just a random sample of English words, or perhaps of letters, put together without any purpose, deliberation, plan, or intention.

The idea that the only alternative to determinism is just sheer chance was taken over by Schlick, together with many of his views on the subject, from Hume, who asserted that 'the removal' of what he called 'physical necessity' must always result in 'the same thing with *chance*. As objects must either be conjoin'd or not, . . . 'tis impossible to admit of any medium betwixt chance and an absolute necessity'.[41]

I shall later argue against this important doctrine according to which the only alternative to determinism is sheer chance. Yet I must admit that the doctrine seems to hold good for the quantum-theoretical models which have been designed to explain, or at least to illustrate, the possibility of human freedom. This seems to be the reason why these models are so very unsatisfactory.

Compton himself designed such a model, though he did not particularly like it. It uses quantum indeterminacy, and the unpredictability of a quantum jump, as a model of a human decision of great moment. It consists of an amplifier which amplifies the effect of a single quantum jump in such a way that it may either cause an explosion or destroy the relay necessary

[40] See M. Schlick, *Erkenntnis*, 5, p. 183 (extracted from the last eight lines of the first paragraph).

[41] Hume, op. cit., p. 171. See also for example p. 407: '. . . liberty . . . is the very same thing with chance.'

for bringing the explosion about. In this way one single quantum jump may be equivalent to a major decision. But in my opinion the model has no similarity to any *rational decision*. It is, rather, a model of a kind of decision-making where people who cannot make up their minds say: 'Let us toss a penny.' In fact, the whole apparatus for amplifying a quantum jump seems rather unnecessary: tossing a penny, and deciding on the result of the toss whether or not to pull a trigger, would do just as well. And there are of course computers with built-in penny-tossing devices for producing random results, where such are needed.

It may perhaps be said that some of our decisions *are* like penny-tosses: they are snap-decisions, taken without deliberation, since we often do not have enough time to deliberate. A driver or a pilot has sometimes to take a snap-decision like this; and if he is well trained, or just lucky, the result may be satisfactory; otherwise not.

I admit that the quantum-jump model may be a model for such snap-decisions; and I even admit that it is conceivable that something like the amplification of a quantum-jump may actually happen in our brains if we make a snap-decision. But are snap-decisions really so very interesting? Are they characteristic of human behaviour—of *rational* human behaviour?

I do not think so; and I do not think that we shall get much further with quantum jumps. They are just the kind of examples which seem to lend support to the thesis of Hume and Schlick that perfect chance is the only alternative to perfect determinism. What we need for understanding rational human behaviour—and indeed, animal behaviour—is something *intermediate* in character between perfect chance and perfect determinism—something intermediate between perfect clouds and perfect clocks.

Hume's and Schlick's ontological thesis that there cannot exist anything intermediate between chance and determinism seems to me not only highly dogmatic (not to say doctrinaire) but clearly absurd; and it is understandable only on the assumption that they believed in a complete determinism in which chance has no status except as a symptom of our ignorance. (But even then it seems to me absurd, for there is, clearly, something like partial knowledge, or partial ignorance.) For we know that even highly reliable clocks are not really perfect, and Schlick (if not Hume) must have known that this is largely due to factors such as friction—that is to say, to statistical or chance effects. And we also know that our clouds are not perfectly chance-like, since we can often predict the weather quite successfully, at least for short periods.

XI

THUS we shall have to return to our old arrangement with clouds on the left and clocks on the right and animals and men somewhere in between.

But even after we have done so (and there are some problems to be solved before we can say that this arrangement is in keeping with present-day physics), even then we have at best only made room for our main question.

For obviously what we want is to understand how such non-physical things as *purposes*, *deliberations*, *plans*, *decisions*, *theories*, *intentions*, and *values*, can play a part in bringing about physical changes in the physical world. That they do this seems to be obvious, *pace* Hume and Laplace and Schlick. It is clearly untrue that all those tremendous physical changes brought about hourly by our pens, or pencils, or bulldozers, can be explained in purely physical terms, either by a deterministic physical theory, or (by a stochastic theory) as due to chance.

Compton was well aware of this problem, as the following charming passage from his Terry Lectures shows:

> It was some time ago when I wrote to the secretary of Yale University agreeing to give a lecture on November 10 at 5 p.m. He had such faith in me that it was announced publicly that I should be there, and the audience had such confidence in his word that they came to the hall at the specified time. But consider the great physical improbability that their confidence was justified. In the meanwhile my work called me to the Rocky Mountains and across the ocean to sunny Italy. A phototropic organism [such as I happen to be, would not easily] . . . tear himself away from there to go to chilly New Haven. The possibilities of my being elsewhere at this moment were infinite in number. Considered as a physical event, the probability of meeting my engagement would have been fantastically small. Why then was the audience's belief justified? . . .

They knew my purpose, and it was my purpose [which] determined that I should be there.[42]

Compton shows here very beautifully that mere physical indeterminism is not enough. We have to be indeterminists, to be sure; but we also must try to understand how men, and perhaps animals, can be 'influenced' or 'controlled' by such things as aims, or purposes, or rules, or agreements.

This then is our central problem.

XII

A CLOSER look shows, however, that there are *two* problems in this story of Compton's journey from Italy to Yale. Of these two problems I shall here call the first *Compton's problem*, and the second *Descartes's problem.*

Compton's problem has rarely been seen by philosophers, and if at all, only dimly. It may be formulated as follows:

There are such things as letters accepting a proposal to lecture, and public announcements of intentions; publicly declared aims and purposes; general moral rules. Each of these documents or pronouncements or rules has a certain content, or meaning, which remains invariant if we translate it, or reformulate it. Thus *this content or meaning is something quite abstract.* Yet it can control—perhaps by way of a short cryptic entry in an engagement calendar—the physical movements of a man in such a way as to steer him back from Italy to Connecticut. How can that be?

This is what I shall call Compton's problem. It is important to note that in this form the problem is neutral with respect to the question whether we adopt a behaviourist or a mentalist psychology: in the formulation here given, and suggested by Compton's text, the problem is put in terms of Compton's *behaviour* in returning to Yale; but it would make very little difference if we included such mental events as volition, or the feeling of having grasped, or got hold of, an idea.

Retaining Compton's own behaviourist terminology, Compton's problem may be described as the problem of the influence of the *universe of abstract meanings* upon human behaviour (and thereby upon the physical universe). Here 'universe of meanings' is a shorthand term comprising such diverse things as promises, aims, and various kinds of rules, such as rules of grammar, or of polite behaviour, or of logic, or of chess, or of counterpoint; also such things as scientific publications (and other publications); appeals to our sense of justice or generosity; or to our artistic appreciation; and so on, almost *ad infinitum.*

I believe that what I have here called Compton's problem is one of the most interesting problems of philosophy, even though few philosophers have seen it. In my opinion it is a real key problem, and more important than the classical body-mind problem which I am calling here 'Descartes's problem'.

In order to avoid misunderstandings I may perhaps mention that by formulating his problem in behaviouristic terms, Compton certainly had no intention of subscribing to a full-fledged behaviourism. On the contrary, he did not doubt either the existence of his own mind, or that of other minds, or of experiences such as volitions, or deliberations, or pleasure, or pain. He would therefore have insisted that there is a *second* problem to be solved.

We may identify this second problem with the classical body-mind problem, or Descartes's problem. It may be formulated as follows: how can it be that such things as states of mind—volitions, feelings, expectations—influence or control the physical movements of our limbs? And (though this is less important in our context) how can it be that the physical states of an organism may influence its mental states?[43]

Compton suggests that any *satisfactory* or *acceptable* solution of either of these two problems would have to comply with the following postulate which I shall call *Compton's postulate of freedom*: the solution must explain freedom; and it must also explain

[42] Cp. *The Freedom of Man*, pp. 53 f.

[43] A critical discussion of what I call here Descartes's problem will be found in chapters 12 and 13 of my book *Conjectures and Refutations.* I may say here that, like Compton, I am almost a Cartesian, in so far as I reject the thesis of the physical completeness of all living organisms (considered as physical systems), that is to say, in so far as I conjecture that in some organisms mental states may *interact* with physical states. (I am, however, less of a Cartesian than Compton: I am even less attracted than he was by the master-switch models; cp. notes 44, 45, and 62.) Moreover, I have no sympathy with the Cartesian talk of a mental *substance* or thinking *substance*—no more than with his material *substance* or extended *substance.* I am a Cartesian only in so far as I believe in the existence of both, physical *states* and mental *states* (and, besides, in even more abstract things such as states of a discussion).