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# Lecture 1

## Science and Reality.

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The subject of this lecture is to introduce to you a conception which has for two and a half millennia been the guide of all major efforts to understand nature, but which has been repudiated by the modern interpretation of science. I mean the conception of reality. Rarely if ever will you find it taught today that the purpose of science is to discover the hidden reality underlying the facts of nature. The modern ideal of science is to establish a precise mathematical relationship between the facts without acknowledging that such a mathematical relationship is of interest to science only because it is a sign that we have hit upon a feature of reality. My purpose is to bring back the idea of reality and place it at the center of a true conception of scientific enquiry, and of science itself. Admittedly, the resurrected idea of reality will look very different from its defunct ancestor. Instead of being the absolutely clear and firm ground of all appearances, it will turn out to be known to us quite vaguely, with an inexhaustible range of expectations attached to it.

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It is common knowledge that Copernicus overthrew the ancient view that the sun and the planets go round the earth and that he established instead the system in which it is the sun that is the center around which all planets circle, and the earth itself goes round the sun as one of the planets, on a par with them.

But do not find it recognised, that it was by the way this discovery was interpreted by Copernicus and his immediate followers, that the metaphysical foundations of modern science were established. The decisive issue between the Copernicans and their critics was, whether the heliocentric was real. Whether it was no more than a new computing device, but was as the Copernicans affirmed it, a real image of the sun and the planets in motion.

For thirty years Copernicus hesitated to publish his theory, because he dare not oppose the teachings of Aristotle by affirming that the heliocentric system he had set up was real. Two years before the publication of his book in 1543, a protestant clergyman called Osiander commented on the preliminary communications of Copernicus' system by a letter urging Copernicus to acknowledge that science can only produce hypotheses representing the phenomena without claiming to be true. Later, Osiander succeeded in introducing an Address to the Reader into the published book of Copernicus, expressing the same philosophic views as before and denying the reality of the Copernican system. And the issue was still the same over half a century later in Kepler's defence of Tycho Brahe against his critics and above all, almost a century later in the conflict between Galileo and Cardinal Belarmine, representing the Pope and the Inquisition. The conflict was due entirely to Galileo's refusal to accept the view that the heliocentric system was merely a convenient hypothesis, and not a statement of fact.

It is strange, that about the turn of the last century the modern criticism of science initiated by Ernst Mach and vigorously supported by Henri Poincaré, could coolly declare that the claim which Copernicus, Kepler and Galileo so bitterly defended was in fact illusory. They taught that science consists in establishing functional relations between facts and that anything that goes beyond this is undemonstrable. To speak of a reality underlying these relations was a metaphysical statement, without substantial content and irrelevant to science.

During the past half century these earlier statements of positivism have been first sharpened into logical positivism and then toned down again by various qualifications which so far as I can see give up any attempt at defining the nature and justification of natural science. There has been sharp opposition to the positivist movement by individual writers, particularly the recently deceased great historian of science, Alexandre Koyre, supported up to a point by Margenau and Gerald Holton. But I see no recognition of the fact, which I propose to tell you about in these lectures, that the great achievement of the Copernican revolution was that it established the true metaphysical foundations of science, on which modern science still rests.

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I shall try to explain what made Copernicus feel that the new system he proposed was real. For this purpose, I shall give you the simplest possible image of a particular feature of the old system and a greatly simplified version of the way the new system dealt with the same subject.

When you watch the position of a planet from a point in the northern hemisphere, you see its position shifting night after night through the firmament of fixed stars. It moves predominantly from west to east; but not steadily; it speeds up, slows down, even retraces its steps and the continues eastwards again. It passes through these retrogressions at regular intervals. The Ptolemaic system explained these retrogressions by assuming that the planet instead of circling round its orbit is carried round it sitting on the edge of a wheel. While this wheel circles round planet's orbit, it keeps turning round its axle and produces thereby loops in the planet's motion round its orbit. These loops are seen from the earth as retrogressions. Such wheels are known as epicycles, and the particular type I am describing are the major epicycles. The effect of epicyclical motion can be understood best by assuming that the planet has for the moment discontinued its main eastward motion around its orbit. Viewed from the earth at rest, the image of the planet among the fixed stars will oscillate then at the rate of its passage around the epicycle. Add then to the oscillation once more the orbital motion to the east and you obtain the retrogression or looping as observed from the earth.

The fundamental idea of Copernicus was that instead of having the planets circling on epicyclical wheels, we can get the same effect by putting the earth into a circular motion round the sun. You can see how this works if you imagine once more a planet arrested in its orbital motion and trace then its image in the firmament of stars. The image oscillates in the same way as the planet was seen to oscillate in the Ptolemaic system. And if we add once more to this oscillation the eastward orbital motion of the planet, we get the observed looping explained. It is explained now as a mere illusion, without any epicyclical motion.

I will invite you now to put yourself mentally into the position of the thirteen centuries preceding Copernicus. Though it is not easy to find indications of this in the writings of this age, I feel sure that astronomers has noticed two things about the epicycles. First, all the wheels representing epicycles were seen to go round at the same rate and this period was equal to one year. In consequence of this a planet like Mars, circling its orbit in about two years passes through two loops a year, while Jupiter which rounds its orbit in 12 years passes through 12 loops and Saturn which takes 30 years to go round makes 30 loops on the way. Second, the apparent size of the wheels representing the observed loops was observed steadily to decrease with the increasing length of orbital periods from Mars, through Jupiter, to Saturn. Moreover it seemed reasonable to assume that all the planets move about the same speed and that if some take longer to go round their orbit, this is because their orbital circles are larger. So the orbit of Saturn must be largest, Jupiter have a smaller orbit and Mars' orbit must be smaller still.

You will now see that all three features of the old system follow from the Copernican theory. In the <u>first place</u>, it is obvious that, since epicycles are replaced by an illusory oscillation due to the annual motion of the earth round the sun, this oscillation must always take place at the same rate, equalling one year. The <u>second point</u>, the difference in the angle of oscillations, arises now by placing the several planets at different distances from the earth. Indeed, in order to explain any particular angle of oscillation, <u>we must</u> place the planet at a definite distance. In other words, the theory fixes the solar distance of each planet in proportion to the solar distance of the earth, and this yields our <u>third point</u>: It confirms the ancient surmise, that the size of planetary orbits gets steadily larger as the orbital period gets longer.

Such was thetriumph of Copernicus. The major epicycles were wiped out as illusory. The equality of their periods and the fact that they equal one year is deduced and the fact that the angle of oscillation of the planetary loops decreases as the period of orbital period increases is accounted for by placing the several planets at appropriate distances as a result of which we obtain a sequence of solar distances which increases with the orbital periods, as had always been thought to be reasonable. All this was deduced from the one single idea of placing the sun as the center of the planetary system and moving the earth from the center into the position of a planet circling round the sun.*

It is on the success of this fundamental idea, setting aside the infinite complications of its ultimate execution, that Copernicus based his claim that his system was real. In the preface addressed to Pope Paul III he writes that he has

> at last discovered that, if the motions of the rest of the planets be brought into relation with the circulation of the Earth and be reckoned in proportion to the orbit of each planet, not only do their phenomena presently ensue, but the orders and magnitudes of all stars and spheres, nay the heavens themselves, become so bound together that nothing in any part thereof could be moved from its place without producing confusion of all the other parts and of the Universe as a whole.

Everything is now bound together, he claims, and this is a sign that the system is real. Other passages are more specific, but the analysis I have given is but my own reconstruction of the result Copernicus had in mind, no exact specification of it is given in his book. He speaks fervently of the harmonies he has established but gives no precise definition of its claims.

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* This account of the Copernican system is admittedly much abbreviated by disregarding for the moment the two planets Mercury and Venus the orbits of which lie inside the orbit of the earth. Suffice to say, that these fit in with the picture I have given and thus strengthen further the principles of the Copernican system.

It is recorded that Petrarca, living in the neighbourhood of Avignon early in the fourteenth century, was one of the first mounteneers and climbed the Mont Saint Victoire, famous by Cezanne's painting of it. But so novel was the rapture he felt,that he would find no words for it, though every schoolboy had them ready today. Faced with his unprecedented achievement of a great scientific discovery, Copernicus was incapable of telling clearly what had deeply convinced him. But today it is clear that what he discovered was a coherent image of previously scattered features and this was what convinced him that he was facing the true nature of the planetary system.

But why exactly did this claim evoke such protest among his contemporaries, particularly by the clergy? The medieval teaching which clerics from Osiander to Belarmine defended, goes back to Aristotle. It derived all essential features of the universe from necessary first principles, such as the perfection of creation. For example, the divine perfection of steady circular motion required, that the course of all heavenly bodies be constructed from such motions. Copernicus himself insisted on this at the cost of introducing absurd complications into his system. Even Galileo adhered to it. This view excluded the possibility of for discovering ultimate features of nature by the empirical observations of the astronomer. Only philosophy was competent to reach such conclusions. Centuries later the positivists declared once more that science can say nothing about ultimate reality, but theirs was a very different reason, namely that any such claim was meaningless. Their purpose was to purify science of such empty metaphysical implications.

The meaning of these two different attacks on Copernicanism the medieval and the positivist attacks, and the position of Copernicus himself can be illustrated by a diagram. The medieval position shows reason as conceived by them, bearing directly on reality, while barring science from any such bearing. The positivist movement is shown isolating sdience both from basic reason and from reality. Regarded as a convenient relation of given facts, science is self contained. Copernicanism is shown, thirdly, claiming to apply basic reason through empirical science for discovering reality.

Copernicus has made for the first time the metaphysical claim that science can discover new knowledge about fundamental reality and this claim triumphed in the Copernican revolution. Later the claim of science to know reality was disowned by the positivist critique of metaphysics; I myself agree with Copernicus. In my opinion it is impossible to pursue science without believing that it can discover reality and I want to re-establish his belief.

Let us try to understand then what Copernicus believed by saying that his system was real. We shall find a clue to this if we first look at a more active form of this belief which Kepler and Galileo have manifested when undertaking their enquiries. They testified to their belief that the Copernican system was real, by relying on it as a guide to discovery. We know that this confidence proved justified. I shall show this for Kepler. His Third Law, discovered sixty six years after the death of Copernicus, developed the feature of the heliocentric system, which Copernicus mentioned as its most striking harmony, namely the fact that all six planets recede steadily further from the sun in the sequence of their longer orbital periods. Kepler lent precision to this relationship by showing that the cube of solar distances is proportional to the square of the orbital periods. His other great discovery, made ten years earlier of his First and Second Laws, was in a sense a departure from Copernicus. It broke away from the doctrine of steady circular planetary motions and introduced instead an elliptic path and a law of variable velocities related to the ellipse. Yet this elliptic path, with the Sun in one focus of it, was firmly tied to the heliocentric system. It could never have been discovered from Ptolemy's image of the planetary system.

I would not hesitate to say that these discoveries proved the reality of the Copernican system but this is because I know what Newton discovered towards the end of the same century, namely that these three laws of Kepler were expressions of the law of universal gravitation. At the time Kepler put his laws forward, mixed up with a number of other numerical rules that proved fallacious, the effect of his three laws was not widely convincing; Galileo himself was unimpressed by them. But for the moment I can set this aside, for I am only trying to understand what Kepler and Galileo believed about the Copernican system, when they relied on their conviction that it was real and therefore a proper guide to their enquiries.

In a sense it is easy to see what happened in Kepler's and Galileo's thought. Relying on the reality of the Copernican system, they recognised the presence of problems, which after many years were to prove fruitful. But how did the Copernican system indicate to them good problems that where not visible in the Ptolemaic system?

This raises a general question, which to my knowledge, has never been systematically examined. The question is: What is a problem? Not the kind of problem set to students of mathematics or to chemists in practical classes but a scientific problem the solution of which is unknown; and yet a problem the scientist may embark on with a reasonable hope to discover something new that will be worth the labour and expenses of the search for it.

I would answer that to have such a problem, a good problem is to surmise the presence of something hidden, and yet possibly accessible, lying in a certain direction. Enquiry stats with such a vague surmise and it may still remain uncertain to the end what exactly might be discovered by its pursuit. Such a problem is evoked in the imagination of a scientist by a set of circumstances which he recognises as clues to something hidden. And when the problem is solved these clues will be seen to form part of the hidden thing thus discovered. The clues of a problem thus anticipate aspects of a future discovery and guide the questing mind to make the discovery.

We can say then that Kepler's feeling that the Copernican system was real, was expressed by his belief that its image anticipated aspects of something still hidden, that might be accessible by research in certain directions. And we may add, that Kepler's discoveries similarly raised problems in Newton's mind by the fact that Kepler's laws anticipated aspects of the still hidden laws of gravitation, which Newton was to discover. Thus Newton too was guided by a belief in the reality of the Copernican system.

The belief which the followers of Copernicus placed in the reality of the Copernican system consisted then in imputing to it still hidden implications, vaguely suggested by the presence of possible anticipations sensed in certain features of the system. Their belief in its reality was a feat of the questing imagination, essential to their creative achievement.

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Let us take stock of the position we have reached. In the history of the Copernican Revolution we have found it possible to discriminate the explicit statements of the theory from its anticipatory powers. The celestial time-table set out by Copernicus was not markedly different from that of Ptolemy. Close on to a century following the death of Copernicus, all efforts to discriminate convincingly between the two systems on the grounds of their observable quantitative predictions have failed. While the discoveries of Kepler and Galileo based on the heliocentric system greatly increased its plausibility and eventually convinced most astronomers, the general effect, judged for example by the responses of Bacon and Milton, was not conclusive. Yet all this time the theory of Copernicus was exercising heuristic powers totally absent in the system of Ptolemy. We are faced there with the question how one of two theoretical systems, having the same explicit content, can vastly exceed the other in its anticipations.

The answer is there already in my description of the anticipatory suggestions offered by the Copernican system. Its anticipatory powers lay in the new image by which Copernicus represented the predictive content of the Ptolemaic system. It is in the appearance of the new system that lay its immense superiority; it is this image that made the Copernican revolution.

I am drawing here a distinction which will prove decisive. I distinguish between the precise predictive content of a mathematical theory consisting in a functional relation of measured variables and a meaning of the theory which goes beyond this. While these functional relations remain the same, the surplus of meaning which goes beyond them may vary with the appearance of the theory.

The way this may come about can be illustrated from everyday life. Suppose we have a list of all the towns of England, each with its precise longitude and latitude, and the number of its inhabitants and we now represent these data in a map, each town being marked by a circle corresponding to it in size. The mapping of the list adds no new data to it, yet it conveys a far deeper understanding of these data. It reveals for example the way the population is distributed through the country and suggests questions about the reasons of physical geography and history which will account for this distribution. The map will guide the imagination to enter on fruitful enquiries to which the original list would leave us blind.

E. M. Foster has shown a similar difference between two kinds of characters in a novel. There are flat characters whose behavior can be precisely predicted and round characters which develop creatively; the latter are more real and hence have the power convincingly to surprise us. By bearing on reality, scientific theories also have the power convincingly to surprise us.

But before going further, I must yet enter a caveat. The distinction between explicit content and informal heuristic powers is profound, but not absolute. No mathematical theory means anything except as understood by him who applies it, and such an act of understanding and applying is no explicit operation; it is necessarily informal. Great discoveries have indeed been made by merely finding novel instances to which an accepted theory applies. Vant' Hoff's discovery that the mass action law of chemistry was an instance of the Second Law of thermodynamics was a fundamental achievement.

When I speak of the explicit content of a theory, I refer to such applications of it which, though informal, are fairly obvious

These I distinguish from the yet indeterminate meaning of the theory that may be revealed only much later, by a creative act of a scientist's imagination. This type of discovery is also based on a firm belief in the bearing which an accepted theory has on reality.

But was Copernicus himself, when expressing his belief in the reality of his system, in fact asserting that it had anticipatory powers, which the Ptolemaic system had not? It is not clear how anticipatory powers can be known at all, except in the act of relying on them as clues to an enquiry. Copernicus certainly did not know that his system represented an aspect of Kepler's laws and of Newton's theory of general gravitation. Indeed, being wedded to an explanation of the planetary system in terms of steady circular motions, he would have absolutely rejected Kepler's Law and Newton's theory based on them.

Yet his belief that his system was real, was basically akin to that of his great successors. For he based his claim on those features of his system which were to serve as clues to the problems of Kepler and Newton. He cited in its favour the regular increase of orbital periods with increasing distance from the sun and also the position of the sun at the center controlling the whole order of planets.

But there is a more general kinship between the commitment of Copernicus to his belief that his system was real and that of his followers who relied on it for their problems. What Copernicus believed of his system, certainly included what we commonly mean by saying that a thing is real and not a mere figment of the mind. We mean then that the thing will not dissolve like a dream, but that, in one way or another it will yet manifest its existence inexhaustibly in the future. It is there, whether we believe it or not, persisting independently of us, and hence never fully predictable in its consequences. The anticipatory powers which Kepler, Galileo and Newton revealed in the heliocentric system, were but more precise details of the general anticipations that are intrinsic to any belief in reality.

We may indeed define reality and truth as follows. If anything is believed to be capable of a largely indeterminate range of future manifestations, it is thus believed to be real. A statement about nature is believed to be true if it is believed to disclose an aspect of something real in nature. A true physical theory is, therefore, no mere functional relation between observed facts, but represents an aspect of reality, which may yet manifest itself inexhaustibly in the future.

But we must yet explain the fact that the general appearance of the Heliocentric system made Copernicus and his followers believe that it was real. It was its close coherence, its intellectual harmonies that had this power over them.

For the existence of a harmonious order is a denial of randomness; order and randomness are mutually exclusive. And we may add that anything that is random is meaningless, while anything that is orderly is meaningful.

Take the difference between a tune and a noise; or, more generally, between a message and a noise. Communication theory defines a noise, by contrast to any distinctive series of signals, as a random sequence and it says that, as such, noise conveys no information - means nothing.

Note also an important difference in the identifiability of an ordered sequence, as compared with a noise. Any single message is represented ideally by only one configuration of signals, while for a noise the very opposite holds. No significance must be attached to any particular configuration of signals that are a noise. We must indiscriminately identify any particular configuration of a noise with any other configuration of it. And this is true of any random aggregate: the chance events which compose it could have as well happened otherwise. By contrast, once we have recognised an aggregate of events as orderly and meaningful, we do not think that they might just as well have happened diffe-rently. Such an aggregate is deemed an identifiable thing, posses-sing reality in the sense I have defined it; namely, that it may yet manifest itself inexhaustibly in the future. To distinguish meaningful patterns from random aggregates is therefore to exer-cise our power for recognising reality.

Our capacity for discerning meaningful aggregates, as distinct from chance aggregates, is an ultimate power of our per-sonal judgment. It can be aided by explicit argument but never determined by it: our final decision will always remain tacit. Such a distinction may be so obvious, that our tacit powers are used effortlessly and their use remain unnoticed. Our eyes and ears continuously commit us to such decisions automatically. But other decisions of this kind may be hard and momentous. A jury may be presented with a pattern of circumstantial evidence pointing to the accused. It is always conceivable that this pattern may be due to chance. How unlikely a chance should they admit to be possible? Or else, what degree of coincidence should be deemed quite unbelievable? The prisoner's life and the administration of justice will depend on the decision, and there is no rule by which it can be decided.

I have said that reality in nature is a thing that persists and may yet manifest itself unexhaustibly, far beyond our present ken. Something must be added to this description, if the pursuit of natural science is to be justified. Consider that the Copernican revolution was but a continuation of a structuring that had its origins in antiquity. Copernicus deepened and beautifully clarified a coherence transmitted by Ptolemy. And this triumph pointed beyond itself in the mind of Copernicus himself. In Kepler, passionately embracing the system of Copernicus, its image evoked anew the same kind of creative hunger which Copernicus had satisfied by discovering it. And the presence of yet hidden truth worked its way ever further. To Newton, Kepler's three laws appeared to hang together and he established this by his theory of gravitation which jointly derived them from the mechanics of Galileo. Nor was this the end, for a quarter of a millennium later, Einstein was to find unsatisfying the relation of the Newtonian system to the electromagnetic theory of light and was to discover an even deeper coherence to reconcile the two.

The continued pursuit of science is possible, because the structure of nature and the capacity of the human mind to grasp this structure, can be such as is exemplified by this sequence of discoveries during the past two thousand years. It is frequently the case, that nature is capable of being grasped in successive stages, each of which can be reached only by the highest powers of the human mind. Consequently, to discover a true coherence in nature is often not only to discern something which, by the mere fact of being real, necessarily points beyond itself, but to surmise that future discoveries may prove its reality to be far deeper than we can imagine at present.

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It may sound strange that I insist on a belief in the reality of theoretical suppositions as the driving force to discovery. Such belief would seem a conservative assumption, rather than a source of innovation. The positivist view of science would indeed claim that the major discoveries of modern physics were based on a sceptical attitude towards the framework of hitherto accepted scientific theories. The discovery of relativity involved the abandonment of the current conceptions of space and time, and quantum mechanics achieved its breakthrough by discarding the planetary system of electrons circling the nucleus, from which Niels Bohr had derived the theory of atomic spectra. Einstein himself acknowledged that Mach's positivist philosophy had inspired his work and Heisenberg's quantum mechanics was deliberately framed to reduce atomic theory to a functional relation of observable quantities.

These facts may seem to contradict my thesis, but I think they will fall in line with it, if I first make clearer the opposite extreme of creative procedure, based on a firm belief in the reality of the current framework of scientific theory. We may recognise the prototype of such a feat in the discovery of America by Columbus. He triumphed by taking literally, and as a guide to action, that the earth was round which his contemporaries held vaguely and as a mere matter of speculation. The egg of Columbus is the proverbial symbol for such breath-taking originality guided by a crudely concrete imagination. I remember having the same feeling when first hearing of Einstein's theory of Brownian motion. The idea that the meandering oscillations of small floating particles seen under the miscroscope, should reveal the impact of molecules hitting them in accordance with the speculative equations of the kinetic theory of gases, impressed me as grossly incongruous. I had the same feeling of something fantastic, when I heard Elsässer suggesting (in 1925) that certain anomalies observed in the scattering of electrons by solids may be due to the optical interference of their de Broglie waves. We had all heard of these waves since 1923, yet were astounded by the fact that they could be taken literally as Elsässer did.

This may remind us that the first great move towards the discovery of quantum mechanics was de Broglie's idea of the wave nature of matter. This revolutionary idea and Schrödinger's development of it into wave mechanics, shows no trace of any positivistic influences. Add to this, that Max Planck, the founder of quantum theory, actively opposed Mach's analysis of science and dissented from Heisenberg's claim of basing physical theories on directly observable quantities,[1] and that Einstein himself, whose principle of relativity served as an inspiration to modern positivism, was sharply critical of it.[2] It appears then, that the pre-dominant principle that shaped modern physical theory was not the positivist program, but the transition from a mechanical conception of reality to a mathematical conception of it, which sometimes coincided with positivistic aims.

We can bring thus the revolution of the twentieth century into line with the Copernican revolution of the 16th and 17th century. They both consisted in a stepwise deepening of coherence with a simultaneous extension of its range. The modern revolution differed from its precursor in establishing mathematical harmonies in place of beautiful mechanical systems.

The mathematical image of reality is more abstract than the mechanical, but its capacity to point beyond its immediate predictive content is similar to that of the mechanical image. I have said that the fact that the wave nature of particles postulated by de Broglie could be confirmed by diffraction experiments, came as a fantastic surprise to physicists. The discovery of the positron came about just as unexpectedly to confirm a prediction contained unnoticed in Dirac's quantum theory of the electron (1928).

In my account of the Copernican revolution and of the modern revolution in physics, I have mentioned only in passing the contributions made by new experimental observations. But the examples I gave were typical of the way at this time experiments followed their theoretical anticipation, the connection being often not recognized at first. Theoretical speculation and experimental probing entered jointly into a persistent quest towards an ever broader and deeper coherence.

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This remark brings up the question, how the actual process of discovery is performed. Much has been written about this with which I disagree, but for the moment I can put my own views only quite summarily. To see a good problem is to see something hidden and yet accessible. This is done by integrating some raw experiences into clues pointing to a possible gap in our knowledge. To undertake a problem is to commit one-self to the belief that you can fill in this gap and make thereby a new contact with reality. Such a commitment must be passionate; a problem which does not worry us, that does not excite us, is not a problem; it does not exist. Without such passionate commitment no supporting evidence will turn up, no failure to find such evidence will be felt, no conclusions will be drawn and tested, no quest will take place. Evidence is cast up only by a surmise, a hope of the truth which as such, necessarily seeks its own fulfilment. This is how the anticipatory powers I have shown at work in a historical perspective, arouse and guide individual creativity.

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In these lectures I want to define the mental powers by which coherence is discovered in nature. This will establish the theoretical grounds of scientific enquiry, guided by anticipations of reality.

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But this is not enough. The triumph of coherence achieved by the Copernican Revolution filled those brought up on the Medieval order of the universe with dismay. The earth's central position which had been the symbol of man's destiny as the only thinking morally responsible being, was lost. Gone was the divine perfection of an immutable firmament encircling the place where fallen man was ever to strive for salvation beyond this place. "It is all in pieces, all coherence gone", wrote John Donne already in 1611.

The destruction was deepened by the revival of atomism. Dante had said of Democritos that he "abandoned the world to chance." And Dante was right. The assumption that all things are ultimately controlled by the same laws of atomic interaction, reduces all forms of existence to accidental collocations of ultimate particles. There are then no essentially higher things, and no intangible things can be real. To understand the world consists then in representing throughout all that is of greater significance in terms of its less meaningful elements and if possible, in terms of meaningless matter. Accepting this conception of truth and reality man feels himself menaced by his own lucidity and blighted by self-doubt.

The positivist critique of science marks the stage at which the false idea of truth and reality attacks science itself, from which it had originated. If we can overcome these false ideals at this point, this might set an example for our whole outlook and, backed by the very prestige of science, help to overcome scientism everywhere.

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The recognition of anticipatory powers in science has already supplied us with a conception of reality, which transcends the tangible substratum of things. This will allow us to acknowledge higher entities, intangible and yet more real than matter. We shall recognise a hierarchy of being in which man recovers his proper place. He may then feel at home again in the universe.