heavens opened; all through His ministry, He saw the heavens opened; He uncloses the eyes of His followers that they too may see the heavens opened.

In discussions of this Epistle, frequent reference is made to Plato's doctrine of ideas, the doctrine that the things on earth are only shadowy counterparts of the heavenly realities. In the Exodus story the appurtenances of worship were to be made after the pattern shown to Moses on the mount (25^{40}). All through this Epistle we feel that the author has caught from Jesus on the Mount the pattern not only of His worship but of His life; or rather that we must not distinguish between the two, for to Him the life is the worship. Is it not everywhere the hall-mark of Wisdom that her disciples can pierce through the shadows to the substance; that they refuse to be blinded by the glamour of the things they see, or fettered by absorption in the things that pass? One can imagine the thrill with which the worshippers in some house Church would listen to the noble tribute paid in ch. 11 to the heroes of the faith who were in the world but not of the world. They were all Jewish heroes. Had he lived in our day his charity would have taken a broader sweep. He would have recognized all humble and sincere seekers after God everywhere as a great brotherhood which finds its completion only when they can join with this author in the text round which his Epistle is written: 'Let us draw near to God through Jesus Christ.'

Physical Indeterminacy and Human Free Will.

By the Reverend J. H. Morrison, M.A., Aberdeen.

The new conceptions now current in the realm of physical science in regard to the constitution of matter have unexpectedly given rise to a most interesting discussion of the age-long problem of human free will. In particular, certain phenomena connected with radio-activity together with a curious indefiniteness in the position and speed of the electron have led to the conclusion that there is a fundamental loose-jointedness in Nature, and that the atom has a kind of free will such as 'destroys the case for absolutely strict causation.' These ideas have been made common property through the popular writings and persuasive advocacy of Sir James Jeans and Sir Arthur Eddington, and have been acclaimed in theological circles as a charter of liberty. Einstein, however, speaks of them as 'not merely nonsense, but objectionable nonsense.' Planck, also, the doyen of German scientists, than whom there is no higher authority on atomic physics, has argued and protested earnestly against them, both on scientific and on moral grounds, and he agrees that 'Heisenberg himself would be the first to protest against the idea of interpreting his Principle of Indeterminacy as tantamount to a denial of the principle of causation.' [1]

Doubtless the welcome given to the ideas of Jeans and Eddington has been due to the impression in religious minds that it meant the shattering of the iron frame of materialistic determinism and the liberation of the human will. Planck, however, gives it a more sinister interpretation. In the ready acceptance of these new views about indeterminacy he sees an evidence of that spirit of the age which is out to devaluate authority and shake itself free from all the restraints of law. To men of this spirit it is great news to be told that the universe is loose-jointed, that there is a fundamental uncertainty in the constitution of matter and that the reign of law is broken. To them it seems as if the hand of physical science were throwing the gates wide open to unrestricted licence. Religious people, therefore, who are acclaiming with enthusiasm this new doctrine of freedom, would do well to consider in what company they find themselves and whether the road they are travelling may not lead in strict logic to conclusions far different from what they expect. Certain it is that if the universe should prove to be in any wise indeterminate or irrational, if law and order do not control it to its innost core, nobody stands to lose more than the theist.

Here, then, is a matter of vital religious interest upon which one may venture, with a deep sense of the immense difficulty of the subject, to offer some suggestions. And, first, it may be necessary to make some preliminary remarks about the

[1] Max Planck, *Where is Science Going?* 33.

nature of those entities with which atomic science deals.

I. *As it were.*—St. Peter in his vision saw 'as it had been a great sheet knit at the four corners, and let down to the earth.' St. John in the Apocalypse saw 'as it were a sea of glass mingled with fire.' In neither case is it asserted that what they saw had any material existence. And if any one, overlooking or ignoring the caution of the qualifying phrase, '*as it were*,' should go on to argue about the physical composition of the sheet and the glass and the fire he would be liable to fall into very gross error indeed. Now these cautionary words, '*as it were*,' should be written across every page of atomic physics, to remind us continually that we are dealing not with material entities but with mental concepts. Leading physicists are, of course, well aware of this, though even they may at times forget it, but as they cannot be for ever reiterating words of caution, the result is that the general reader gets the impression that the things of which they speak are solid physical entities. This error gives rise to widespread misconception.

In reality, when the physicist speaks of light waves, what he means is that certain phenomena could be best explained if we assume that light consists of multitudinous waves of great frequency and speed. Again, when in other connexions he finds it necessary to speak of light as composed of particles, he means that certain phenomena can best be explained on that assumption. These two concepts cannot be reconciled physically, and if, as has been suggested, we coin a word, 'wavicle,' to cover both, we are simply veiling our ignorance. What it all means is that the physicist, baffled by the mystery of light, can only say that light is '*as it were*' a system of inconceivably rapid waves, and, again, that light is '*as it were*' a stream of minute particles. How much more than this it may be, and what its real nature is, we cannot conceive. The case is similar with the constitution of the atom. Certain phenomena can be explained if we assume that matter is ultimately composed of atoms which in their turn are assumed to contain a nucleus with electrons circling round it. But we must be careful to read into it the cautionary '*as it were*,' to remind ourselves that atoms and electrons are mental constructions. 'It is a historical fact that atoms and electrons have been invented by the human mind to correlate phenomena, and they can never be observed.' [1] The case is the same with the ether and the space-time continuum. The former used to be pictured physically as being at one and the same time frictionless and yet having a density millions of times greater than lead. Now it is conceived of as immaterial or quite dispensed with. The space-time continuum has for its second constituent, not time as is generally supposed, but the square root of minus time multiplied by the velocity of light. Nobody has the faintest idea what that weird construction really stands for, but it provides a useful formula for the physicist in his investigation of this mysterious universe. Beyond that we must take care not to go. 'We cannot attribute any reality to the space of the universe, except again as a mental concept; any attempt to assign a degree of reality different from this to space leads only to confusion and contradictions.' [2]

Here we come on the secret of those 'confusions and contradictions' with which mathematicians and physicists delight to tease us. For example, having assumed that there is an electron revolving round the nucleus of the atom with inconceivable rapidity, they find it necessary to assume, further, that it can jump from one orbit to another in no time at all. So Whitehead compares the motion of an electron to a motor car travelling at thirty miles an hour by the extraordinary procedure of appearing for two minutes at the first milestone and instantaneously thereafter appearing for two minutes at the second, and so on. As physicists, in their laudable desire to popularize the new knowledge, have supplied us plentifully with such illustrations, perhaps the limitations of their reasonings may be set forth in the following way. Suppose the football field were completely veiled from the spectators so that they only see the ball when it was shot through between the goal-posts, they might naturally assume that there was something of the nature of a gun in front of the goal. Hearing, also, mingled sounds from within they might frame a second hypothesis that these sounds proceeded from some sort of a gramophone, and some ingenious mind might go further and suggest that the two might be unified under the name of a 'grammogun.' So far good, but how far short it would fall of describing the centre-forward, and how precarious would be the inferences drawn from such imperfect data! This illustration may appear fanciful, but it is precisely the kind of work that is done when light is described as 'wavicles,' or when it is argued that the electron travelling at such inconceivable speed, if it ran off the rails, would smash the world. Deductions of this sort have been confidently drawn, but we now have it

[1] H. Dingle, *Science and Human Experience*, 90.

[2] J. Jeans, *The New Background of Science*, 293.

on the authority of Lord Rutherford, addressing last year's British Association, that those who reason in that way are 'talking moonshine.'

We must bear constantly in mind the limitations of our knowledge, and remember in particular that while our concept may touch reality at one point it may be wholly inapplicable at another. Physical science, in so far as it has penetrated the secret of matter, finds it best to say that the world is composed *as it were* of atoms, electrons, and protons, but no scientist imagines for a moment that that is the final word, and that matter is just that and no more. A quite different hypothesis may be brought forward which, dispensing altogether with the concept of electrons and atoms, may more adequately express reality. We have no direct knowledge of anything but phenomena which are cast up to the surface out of an unfathomable ocean of reality, the nature of which we can only dimly infer. As Sir James Jeans clearly puts it: 'We must then regard electrons and protons merely as unobservable sources of events which are themselves observable. The millions of electrons and protons in the sun exist only as inferences, created to explain the stream of protons which fall on our eyes and skin all day long.' [1]

II. *The Freedom of an Atom.*—These considerations must be kept steadily in view, and they may help us as we approach the exceedingly difficult and elusive subject of the indeterminacy of the atom. Certain facts of observation have led to the conclusion that the atom is in some degree undetermined and has, in Bertrand Russell's phrase, a sort of free will. What are these facts? First there are certain facts connected with radio-activity. The disintegration of the radio-active substance appears to be 'spontaneous,' as Rutherford and Soddy describe it. The process of disintegration cannot be expedited nor retarded, and no prediction can be made as to which atom will next disintegrate. Here, then, it would appear as if the individual atom had some liberty of action so that it might at some moment, without external compulsion, change its form. The whole period of the disintegration of the substance can be accurately measured, and must, therefore, be determined by law. But the suggestion is made that this is no more than a statistical law, that is to say, a law which gives, over a long period, a degree of probability amounting to practical certainty, but leaves each single case undetermined. It should be noted, however, that such statistical laws are usually 'a subterfuge of human ignorance, necessitated by the inability of our degree of experimental accuracy to investigate the initial conditions accurately.' [2] We can predict the fall of the dice only on the average of an immense number of throws, but nobody doubts that each single throw is rigidly determined by the initial conditions, such as the position of the die and the force used by the player, though these we have no means of measuring. Or again, if drops of water fall periodically from a cistern, nobody doubts that these drops accumulate in a perfectly regular, though unobservable, way. Similarly it is reasonable to think that leading up to the disintegration of each single atom there is a perfectly regular causal process, though we may not be able to observe and measure it.

A more important set of observational facts, however, deals with the inability to define and locate precisely the electron. Heisenberg has shown that we can never define precisely at one and the same time both the position and the speed of an electron. The electron is, as it were, wrapped up in a haze so that its location and speed can only be approximately found. Heisenberg points out that this appears to controvert the famous thesis of Laplace that a perfect intelligence with complete knowledge of the past could infallibly predict the future. If the electron cannot be defined with precision, its future cannot be predicted with certainty. It might be thought that our inability to locate and measure the speed of the electron was simply due to our limited powers of observation, but there is more in Heisenberg's principle than that. All physicists are agreed that we have here, not merely a subjective, but an objective indeterminism. The difficulty is not observational, but the very nature of the electron forbids the possibility of defining its location and speed with precision.

How are we to interpret this, and what inference is to be drawn from it? It may help us if we bear in mind that matter is best conceived as being composed of waves. Wave-mechanics at present hold the field. Now a wave cannot be located at any one point. Consider a wave of sound. It takes the whole wave or vibration to make the sound, and it is meaningless to ask at what point in the wave is the sound precisely located. So with the electron. As Planck says, 'there can be no sense in talking about the state of a particle in the sense of meaning its position and velocity.' [3]

[1] *The New Background of Science*, 177.

[2] Hans Reichenbach, *Atom and Cosmos*, 273.

[3] *Where is Science Going?* 63.

But something more has to be said. In talking of the electron as a wave we are still representing it as something belonging to the material world, whereas we have seen that it is really a mental concept created to explain certain phenomena. As soon as we remember that, we realize that the electron is not a picturable object, and that we are striving to assign a precise locus to that which is in its nature immaterial.

The Principle of Indeterminacy, therefore, does not imply that there is really a loose-jointedness in Nature, or that the electron is a minute particle with some elbow-room and freedom of action. It is rather to be taken as a warning that a mental concept cannot be treated as a material entity. So far from being indeterminate, the electron is quite consistently determined in its refusal to be fitted into the space-time framework. As Niels Bohr has pointed out,[1] if we persist in fitting the electron into the space-time framework we get this unavoidable looseness in the fit, but when we release the electron from this bondage the principle of strict causality remains intact. Sir James Jeans does not dissent from this. He says, 'the apparent absence of determinism may be merely the price we pay for trying to force the real world of Nature into too cramped a framework.'[2] He is no opponent of strict causality. What he and Sir Arthur Eddington repudiate is the doctrine of materialistic determinism according to which all phenomena are conceived as bound together in an endless chain so that each event drags the next after it by some physical compulsion. Modern physicists realize that there is more in Nature than appears on the surface, that phenomena are cast up to the surface by the power of the unobservables, and that the linkages of cause and effect lie hid in that underworld. This implies that causality is a much more spiritual thing than it was formerly thought to be. Einstein says: 'Our present rough way of applying the causal principle is quite superficial. We are like a child who judges a poem by the rhyme and knows nothing of the rhythmic pattern. Or we are like a juvenile learner at the piano, just relating one note to that which immediately precedes or follows. To an extent this may be very well when one is dealing with very simple and primitive compositions; but it will not do for the interpretation of a Bach Fugue. Quantum physics has presented us with very complex processes, and to meet them we must further enlarge and refine our concept of causality.'[3]

[1] In *Nature*, April 14, 1928. [2] *Ibid.* 260–1.
[3] Planck, *ibid.* 203–4.

III. *The Freedom of a Man.*—It would appear, then, that the indeterminacy of the atom has little or no light to throw upon the problem of human free will. It is difficult to see how it should, for even though it were granted that each single atom had a rudimentary freedom of its own, it could scarcely be inferred logically from that that the immense concourse of atoms forming the human body would have a corporate and intelligent will. And even so, that would not be human free will as we understand it. At the same time these new ideas in physics have doubtless done much to break the fetters of materialistic determinism, and to pave the way for a more spiritual conception of causality.

Planck has treated the subject with characteristic care and thoroughness. He accepts in full the principle of causality. 'I have not been able to find the slightest reason, up to now, which would force us to give up the assumption of a strictly law-governed universe, whether it is a matter of trying to discover the nature of the physical, or the spiritual, forces around us.'[4] On the other hand, with equal firmness, he accepts, as 'the highest exercise of our powers of understanding,' the invincible consciousness that our wills are free. The two positions, he argues, are not exclusive of one another. 'The alternative—Is the human will free, or is it determined by a law of strict causality?—is based on an inadmissible logical disjunction.' Laplace's infinite intelligence, able to predict infallibly the course of events, comes very near to the doctrine of predestination as taught not only by Calvin but by Augustine and St. Paul, which has always been held to be compatible with human free will. There would be a contradiction 'only if a man could perfectly see through himself as the eye of God sees through him, for then, on the basis of the law of causality, he would foresee every action of his own will and thus his will would no longer be free. But that case is logically excluded; for the most penetrating eye cannot see itself, no more than a working instrument can work upon itself.' In principle a man may trace the working of causality in the world around him, but he can do this 'only when he is sure that the act of applying the law of causality does not influence the happening itself.' The moment he himself comes on to the stage as an actor, he can no longer view the scene as an impartial spectator.

Now this opens up a very suggestive line of thought. Scientific investigation advances by a process of abstraction, according to which the

[4] *Ibid.* 100.

phenomenon to be studied is isolated from its setting in the universe so that it may be more closely observed. In striving to bring one point into clear focus the scientific observer throws other points into more or less obscurity as being for the present irrelevant. Now the first great act of abstraction is one the importance of which from the human standpoint cannot be exaggerated, though it is generally overlooked. It is that act by which the scientific observer removes himself as a human personality from his field of vision, cancels himself out so that his observation may be as far as possible absolutely objective and impersonal. He takes his seat, as it were, in the grand stand and surveys with keen interest, but yet as a spectator, the action going on in the arena below. To him the universe is a *theatron*, and his knowledge of it is, therefore, *theoria*, theoretic knowledge. This method, needless to say, is for certain purposes invaluable, but it must fail completely to give an adequate philosophy of life. The perspective is all wrong; the total view of the universe is distorted. No man can view life from the grand stand. The scientist is down in the arena with the rest of us, fighting for dear life, and he must take account of his own position and of his own action if he is rightly to comprehend the whole.

One notable result, however, of this theoretic way of looking at things is a tendency to conceive of the universe too objectively, as a system of entities and forces quite outwith the control of the onlooker. It naturally follows that the onlooker, when he comes to think of his own connexion with the whole, tends to conceive of himself as a passive and helpless bit of the mechanism. But, in truth, existence ought not to be conceived passively. It is sheer imagination to picture the universe as something more than the sum total of its parts, a sort of monstrous machine holding men and things in its iron grip. In reality it only controls its parts in the same sense as it is controlled by them. Action and reaction are equal and opposite. Every created thing has its own potency, of which the whole universe must take account. Even a stone where it lies is not wholly passive. If it is struck it can strike back; a man may be dashed to death upon it. It cannot be ignored. In effect it utters the bold challenge, '*Nemo me impune lacessit.*' It is a positive element in the sum total of things, and has its own contribution to make to the grand result. There is a real sense in which the whole universe must reckon with it and arrange itself accordingly.

The same reasoning applies *a fortiori* to the potency of living things, and especially to beings endowed with human powers. These powers must be allowed their full value. It is against all reason to represent a human being as a bit of driftwood helplessly borne along on the current, with no power of resistance and self-assertion. Every unsophisticated man will say, 'My experience contradicts that. The universe may knock me about, but it has to reckon with me. I can co-operate, I can oppose, I can make my mark. I am not a helpless victim; I am an active and responsible partner in the firm. It is certain that up to the limit of my powers I can influence the universe as really as the universe can influence me.'

It is easy to express all this in theistic terms. Creation must involve something of the nature of self-limitation on the part of the Creator. Having once created, He must have respect to His creatures and not infringe the charter of their existence. Were He to override or ignore them, that would be tantamount to their annihilation. This raises for theology the same difficulty as for science, namely, how can the final goal be reached unless every step of the way be rigidly determined. If the least liberty of action be conceded, what safeguard is there against ultimate chaos? There is, as we have seen, an influential body of modern scientists who, rejecting strict determinism, find that the statistical law of averages gives us a degree of probability amounting to practical certainty. 'What happens,' says Reichenbach, 'is not predetermined in all details, as determinism, distorting world history into the mechanical performance of a clock movement, maintains; the course of events is much more like a continual game of dice, so that each separate step corresponds to a new throw. . . . It is of crucial importance that the solid barrier which determinism erects against every non-deterministic solution of the problem of life and freedom has fallen.'[1]

The answer of theology would be somewhat different. Religious faith finds its ultimate ground of assurance in the wisdom and power of God. Life is no game of dice; rather it might be likened to a game of chess, where thought and foresight are involved in every move. Set a mere tyro to play against a master, and though he is free to make any move he pleases, it is certain that he will never win. The master player will always have the game under control and can easily find means of counter-checking every move. Doubtless the illustration is inadequate, as every illustration must

[1] *Atom and Cosmos*, 279.

necessarily be, yet it may help us to form some idea of how the human will may at each point of decision be under no compulsion but able to exercise a free choice, while all the time, in so far as it runs counter to the will of God, it can be effectively held in check. Moreover, we shall be in full accord with the best Christian thought if we go further and say that the human will is in bondage so long as it strives against God. Only when surrendered is it truly free.

In the Study.

Virginibus Puerisque.

A Word.

By the Reverend T. Greener Gardner, Matlock.

'And the Word became flesh, and dwelt among us.'—Jn 1^{14} (R.V.).

One of the very good things my schoolmaster did for me was to interest me in words and their meaning. He gave me pages of words and their derivations to learn, and oftentimes instead of asking questions about them, he would talk about some of those words and their meaning in such a fascinating manner that I envied his knowledge and forgot much of the drudgery. Some of us looked forward to the talks of the master, and are very thankful that he insisted that we should learn so many words and their derivation.

Since those schooldays, I have been very interested in words, and this interest was much aroused the other day when one of my friends sent me a card on which was printed this verse:

> God wove a web of loveliness
> Of clouds and stars and birds,
> But made not anything at all
> More beautiful than words.

When I read that verse I began to think about quite a number of wonderful words and the pictures they brought to my mind. I thought of 'God,' of 'Love,' of 'Father,' of 'Mother,' and a host of others, most of them just small Anglo-Saxon words, but so full of wondrous meaning that I could not tell you all about them in the small space I have for this talk.

Then suddenly my mind ran off to a passage in the Gospel according to St. John—'In the beginning was the Word, and the Word was with God, and the Word was God. . . . And the Word became flesh, and dwelt among us.'

When you are a little older you will probably learn a great deal about the 'Logos,' which is the Greek way of speaking about the 'Word.'

The Greeks had a splendid idea about a word—they thought of a word as being the expression of a living person. A word was speech with a living personality behind it, so that when you read in the Gospel of St. John 'In the beginning was the Word,' you can be quite sure that the writer was endeavouring to say as well as he could, that God had sent Jesus to earth to be the expression of His own heart and mind. Thus in Jesus we know something of the infinite mind and the infinite love of God. Jesus, the living expression of God's thought of men, came to the earth so that men might know God. We love God because we believe that when we know something about Jesus we know something about God Himself.

I think John's manner of telling us about the coming of Jesus is just wonderful. The story of Jesus coming to be cradled in a manger is a very beautiful story, but I think this one of 'The Word becoming flesh and dwelling among us' is also very beautiful, for it means that we may know the love of God expressed in the life of His Son Jesus Christ.

There is something here for all of us to learn; we are to try to be a living expression of the thought of God—A Word of God.

In one of his letters John said that God was love. Jesus came to express God's love for men, and we are to try to copy Jesus. If we do this we may be quite assured that we shall make this earth a much happier place than it is.

What a great honour is ours—to be like Jesus, an expression of the thought of God.

'The Growlery.'

By the Reverend P. N. Bushill, B.A., Orpington.

'I have learned, in whatsoever state I am, therewith to be content.'—Ph 4^{11}.

In a book called *Bleak House*, by Charles Dickens, a book which I am sure you will enjoy reading when you are a little older, there is the story of a