So valuable an ally deserves a better reputation with Christian theologians than Barth and some others would give it, unless better reasons can be adduced against it than have thus far come to light.

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SOME RECENT DEVELOPMENTS IN SCIENCE AND THEIR IMPLICATIONS TO THEOLOGY

WHEN a science professor is to speak to a Theological Conference, he may well wonder with what justification he should say anything at all. For my own part I recall—as my justification—that some years ago one of the cheaper national newspapers did me the honour of reporting a few sentences from an address of mine: this was placed in their 'Quote of the Day', at a time when I was professor of Theoretical Physics at London University. They referred to me then as 'Professor of Theological Physics'!

This is, of course, all a bit ridiculous. Yet perhaps in a world so under domination by science and its ways of thinking, there is something to be said, from time to time, in favour of getting a professional scientist to speak in non-technical terms of some of the recent developments about which he knows. Knowledge of this kind is the necessary preliminary to the sort of sure comment which Christians may, and should, provide. We are not to think of 'proving' the Christian faith by a policy of this kind—nor, of course, of disproving it. But there should be some overlap between the two spheres of thought, and the Church will certainly miss some of the opportunities which a period like the twentieth century offers it if it forgets the saying of Dr Hort—'God will never be fully known until He is known within an understood order of nature'. Physics is physics, without the need for any adjectival qualification. One may not properly call it 'theological', but the London newspaper's error need not be so serious as some theologians might suppose.

I propose to remind you of two or three of the places in which science has sometimes been held to disagree with Christian theology. I want to say what I believe any current up-to-date scientist would say on each of these issues. This will inevitably lead us to some consideration of the status of scientific thinking within the total field of human thought. This status is much misunderstood, both inside and outside the Christian community.

People of my generation were brought up to believe in the inevitability of a conflict between the new science and the old religion. Yet we scarcely need to remind ourselves that it was not always thus. The experimental method, on which all science rests, began in Oxford in the thirteenth century. Round about 1320 our first Chancellor—Robert Greathead, one of the early Franciscans—maintained in his lectures and his sermons that if you wanted to understand God, you needed the language of geometry (today I suppose it would be theoretical physics!). His more famous pupil, Roger Bacon, also a Franciscan, wrote his *Opus Maius* to prove that science could be a best friend of the Church, and aid it in the business of evangelizing mankind. Oxford was not unique in this. St Thomas Aquinas, at about the same time, maintained that the more you knew about the world God made, the more you knew about God, since 'He had impressed a certain image of Himself' upon it.

Such a point of view continued for many centuries. Let me put another Oxford illustration. Most people know of our Royal Society. It was the first—and, as we like to think, still the most distinguished scientific society in the world. It grew from the confluence of two streams. One was in London, the other was here at Wadham College, under the influence of its warden, John Wilkins, later to become Bishop of Chester. But prominent among its earliest members were Christopher Wren, Professor of Astronomy in Oxford, and architect of London after the Great Fire of 1666, unwillingly at the command of King Charles; and there was Robert Boyle the chemist, still remembered by every schoolboy for 'Boyle's Law', yet so devout a churchman that, although he wanted to take Orders, he felt himself unworthy and turned to chemistry instead! Then there was Isaac Newton, probably the greatest scientist of all time. He maintained that his theological studies were the most important of all his work (though perhaps those who have looked at his exegesis of the Book of Daniel might not always agree with his judgement here!). The list could be continued very easily: Thomas Sprat, the rector of one of the leading City churches; Seth Ward, Bishop of Salisbury, and John Ray, the founder of systematic zoology and botany. His great book, *The Wisdom of God Manifested in the Works of Creation* exercised a profound influence in its day. He spoke of Science as a 'proper study for a Sabbath Day', and the book itself, in a slightly expurgated form, was later used by John Wesley in training his travelling preachers.

If all this means anything at all, it means that science grew up in a Christian milieu. William Temple once said that science would not develop in a place where the 'ruling principle of the universe' was supposed to be either 'capricious or hostile'. This may be an exaggeration, but at any rate this was how it did happen over the years.

But we must come to the conflicts. In Britain these came later than in some other places, but the nineteenth century saw them assume significant size. And the irony is that many of them took public shape in the one place where this should not have happened—the British Association. The B.A. was founded in 1831 almost entirely through the efforts of Churchmen. Its avowed intention was to make the new discoveries of science available and understood by the layman, and for that reason it held its meetings each year in a different place, gaining for its members the descriptive epithet of 'peripatetic philosophers'. The proposal to establish it was made by Vernon Harcourt, a distinguished

physical chemist who was interested in the rate at which a chemical reaction proceeds. In his opening speech he maintained that 'true science and true religion ever serve the same great end—the glory and worship of our common Lord'. He was in Holy Orders, and so also were two of its first three presidents. Yet it was among this group that the conflict was most noticeable. Even at the date of its foundation there were rumours—rumblings of discord. Some fifty years earlier Hutton had begun seriously to study the fossils, and therefrom to estimate a likely age for the earth. His pupil, Playfair, had not long been dead when the B.A. was established. Their estimates of the age of the earth began to make Archbishop Ussher's arithmetic look a little pale. Was the Bible trustworthy? Certainly Newton—and all others of his generation—had believed that Creation had taken place in one great burst of divine activity in the year 4004 B C. But scientists of the early nineteenth century had come to disagree with Newton here; why should they trust any part of a book now shown to be seriously in error? (It is, of course, true that at that time they did not know by how much the Archbishop was wrong. In a jocular way it could be said that the age of the earth has been steadily increasing from that day until now, when it is to be measured in thousands of millions of years.) This point of view was argued vehemently at several meetings of the B.A.

This debate was followed by a second one—evolution. Here in Oxford this has a special relevance, since no other public debate on the relation between science and religion has ever had the effect of one held in the Museum, only a hundred yards from my own office, during the 1859 meeting of the British Association. You will find a plaque upon the wall recording that it was in this building that Bishop Wilberforce of Oxford engaged in controversy with T. H. Huxley. Surely this must count as one of the most unhappy episodes in all this conflict. For the Bishop, though undoubtedly a clever man, was no scientist. He was advised by Owen, one of Darwin's rival scientists, a disbeliever in the theory of evolution himself, and a man very willing to let some of his own bitterness flow from the Bishop's lips. Darwin himself was a recluse, and never came to public meetings. But his great warrior, the indomitable, square-faced Thomas Henry Huxley, was there in his place. The result was a catastrophe. For the position taken up by the Bishop, and therefore widely regarded as the true Christian position, was shattered into bits. 'The Lord', said Huxley at one moment, slapping his thigh in pleasure, 'hath delivered him into my hands.'

This debate on the theory of evolution was inevitably followed by a third debate—on free will and determinism. *Man's Place in Nature* was the title of a book of essays by T. H. Huxley, and *The Descent of Man* of a book by Charles Darwin. Man, it seemed, was but part of the animal world; he was to be interpreted in terms of the genes, the hormones, the glandular secretions which gave him no option about himself. His thought, his creative imaginative life, his sense of freedom were illusory—the atoms and electrons of which he was essentially composed, would take care of that. Centuries before all this Democritus had said that after the atoms there was nothing left but a void. His words seemed to fit the mood of a generation that was just rediscovering the atom. So any cross-current, or entrenched interest, which delayed or obscured the understanding of the atom, or dared to question the supremacy of this kind of thinking, was to be rejected out of hand. And the prophets of the new age, like

H. G. Wells and Arnold Bennett, wrote letters to each other, to the effect that 'all religion, of every sort, is dead'.

I have just described three of the fundamental clashes in the science-religion controversy. But before we leave them as mere history, I think it is desirable that we should take them up once more, and look again at them. What would a professional scientist, *qua* scientist, have to say about them in the century which followed the original discussion? Have those first skirmishes become a rout, or are there second thoughts on both sides?

First, then, there is the age of the earth. This is a topic that has been much studied in recent years. For the earth is relatively accessible. We can measure its temperature, and learn how this changes as we go either to great heights above the earth's surface or to great depths below it. We can detect the radioactive changes that go on in the earth's crust, and work backwards to the stage at which these began. We can study the rate at which certain natural deposits occur, and in a dozen or more different ways we can make estimates of the age of the earth itself. One quite extraordinary fact emerges—these various estimates, quite independent of each other, hardly differ significantly the one from the other. It is hard not to put some trust in concordance of this kind. If you deny it, or even seriously doubt it, you are refusing to accept the whole basis on which scientific truth rests. No one—it seems to me—has any right seriously to deny that, according to the best knowledge that we have, the age of the earth is close to 4,000 million years. It may be a bit more, but seems unlikely to be much less. No doubt in a few years time we shall be able to make the figure a little more definite—perhaps add another decimal point. It is of course conceivable that something really fundamental has been left out of our calculations, but the close agreement of so many different approaches makes this possibility rather remote. We had better come to terms with the rather frightening figure that I have quoted. By the side of this huge figure, the length of human life is almost frighteningly small. It is most unlikely that our human ancestors roamed the forests and the swamps more than a million years ago. By comparison with all the ages before human life began, the years since would count as two seconds from a whole day.

Here is a problem which puzzles some people now, as it puzzled the scientists and the Christians of 120 years ago. I mention it now because only a week ago I had the opportunity of engaging in discussion on this very topic with a group of Russian visitors. I was telling them about our Christian faith, and was trying to urge its reasonableness in the light of scientific discovery. One of them turned to me, and he said—without knowing anything of St Augustine and his famous query about what God was doing before He created human beings—'If you say that the earth is so old, and man is so young, what am I to think of your God? Wasn't He wasting His time through all those long years of waiting for the birth of man—real man?' Now, this is a theological issue. For my own part, I take great comfort from the story of Creation and the fact that at the end of each of the first five days of Creation God looked at His work and saw that it was good. It comes to this—that a view of God totally linked with man is not good enough to interpret these long years. Only in one sense were they years of waiting; ages before there were men to take note of its beauty, the sun had set and the moon had waxed and waned, the blossom had been white and cherry

pink. Even the rainbow was a sign of God's concern for His world long before human sin had led to the great Flood. I fancy that here our Christian faith should be at some advantage over at least some of its rivals. For that approving look of God at the evening of those first days is a sign to us that God values the physical order, and not only the human beings which belong to it. The physical universe is not just a stage on which man's little act is played; it is part of the theatre God built with His own hands. In this sense God did not come in Christ to an alien and unfriendly universe. We do not fully understand the Incarnation till we see it as validating scientific inquiry in this way.

So the situation now is vastly different from what it was. We do not worry now, as our grandfathers did, about the significance of the Old Testament as a source-book of scientific truth. And having been saved from this totally unnecessary worry, we are free in a more positive sense to see how the newer discoveries—of an earth 3,000-4,000 million years old, and a universe perhaps twice as old—throw light on the grandeur and majesty of Him who conceived them in the first place. Here, as on other occasions, freedom from an unnecessary worry leads to an enrichment of our total awareness.

But before leaving this matter there are two conclusions that I want to mention. The first is the very remarkable discovery—if one really thinks about it—that this whole enormous universe is a *uni*-verse; that is, that its constituent parts, the atoms of oxygen, nitrogen, hydrogen, etc., are to be found in roughly the same proportions everywhere throughout it, and that their behaviour is characterized by the same laws here on our earth as in the remotest part of this great panorama. There is a distinctive longing for wholeness in the human mind. Some regard it as evidence for God as the Being who can alone unite man's varied hopes. The fact that now, at the physical level of inquiry, this wholeness seems to have been established seems to me further evidence. But, of course, it is not proof.

The other matter is the recognition that quite possibly our earth is not unique. This is in quite direct opposition to older views. It used to be supposed that a planetary system such as ours could only be the product of the near-collision of two stars wandering at random through the icy void. But this is not so now, and today no respectable astrophysicist would entertain such an idea even for a moment. Indeed, it is now widely believed that planetary systems are very frequently associated with stars (e.g. our sun). It may easily turn out that in our own little corner of space—our galaxy, or island universe—there are a million such planetary systems. And we should remember that our island universe is repeated 1,000 million times or more in the rest of space. It would be extremely odd if, in a universe of the character I have just described, there were not some of those millions of possible earths in which the conditions for human life were to be found. By conditions for human life I mean the temperature—not so hot that blood boils, or so cold that it freezes—and the moisture, and an atmosphere of oxygen and similar things. It is true that there is no oxygen on any of the other planets in our own solar system (so far as we know), and most of them are far too cold for our kind of human life. But that does not prevent such conditions being found elsewhere, on other planetary systems, where there may be planets at distances from their sun corresponding to our distance from our sun. We do not know for sure, but it seems highly probable that all the necessary

physical conditions for life exist elsewhere in our great universe. This does not mean that life must also be found there, though expert biologists have given reasons for believing that if the physical conditions are right, and if the necessary atoms are available, then eventually life will arise. Some people, such as Professor Darlington, are prepared to go even further than this, and suggest that in such a case protein would be formed similar to the protein in our own bodies, and that, in the course of time, it is not impossible that we should find creatures with a stage of evolution corresponding closely to ours. Certainly the creation of protein now seems far easier than we once imagined it to be. I can remember reading, some years ago, the calculations of Pierre du Nouy, who tried to estimate the possibility that the correct number of atoms of carbon, nitrogen, oxygen, and hydrogen, rushing about in a kind of random chase, would happen to bump into each other, and stick together to form the first protein molecule. The answer that he got was fantastically small—a conclusion which led some apologists to claim that this was direct evidence of the hand of God. Such inferences are always dangerous, and to be avoided. For certain recent experiments have shown that if you take a cylinder, and fill it with ammonia, methane and carbon dioxide, and if you then pass a single electric spark through it, you will find that even with this simple mixture you have synthesized some of the essential precursors of a protein. We need to be very careful before we use arguments of this kind in defence of the Christian position. God must be seen in the known, and not just as the unknown. I regret that so much use of this idea of God altering the normal way of things has been made in recent years. It is in danger of denying that God is in the ordinary things of this world; and surely that is one of the truths set out for us in the first few chapters of Genesis.

If there really are 'human' beings on some of these other 'earths', we shall meet some very pretty theological issues. How are we to communicate the gospel to them? We have radio waves as our sole mode of physical communication. But these are slow (relative to the great distances involved), and communication is at best rather sporadic if it takes a few thousand years to receive the reply to any question that we ask of the distant stars. Or there may be some form of revelation appropriate to their condition, just as the revelation in Christ is appropriate to ours. We do not know and can scarcely guess, but it is a theological issue, and its dawn is solely the result of modern scientific discovery. What a long way we have travelled from the early form in which this debate about the age of the earth took place!

This leads on to the second of the three great debates which I am here discussing—the theory of evolution. I think it is fair to say about this debate, as was said about the age of the earth, that most of the heat of argument is over, and tempers are cooled. Yet we do well to remember that it was as late as 1925, less than thirty-five years ago, that there took place in Dayton, U.S.A., the famous Scopes trial, with its verdict that the theory of evolution might not be taught by a school biology teacher, because it was contrary to Holy Writ! But just as with the geologists, so now with the biologists—they are more restrained in the claims that they make. Thus in the most recent British book of any seriousness concerned with this problem, the author states that he is forced to accept the theory, *faute de mieux*. There is no rival theory with anything like the comprehensiveness of this theory, different as it is now from the first form in

which Charles Darwin and Russell Wallace put it forward. There are several serious problems connected with it which have not yet been solved, so that, although I personally believe in the theory, I have to admit that all is not clear and straightforward.

Let me mention one of these unresolved problems to show what I mean. We believe with some confidence that the changes which take place in living matter and which reveal themselves as evolutionary and inherited, are dominated by changes in one or more of our genes. The genes—of which we have some 40,000 or 50,000 in each cell—are the carriers of our hereditary characteristics. Under suitable circumstances, such as radiation, or heat, or the action of certain chemicals (e.g. mustard gas), one or more of these genes can be changed, or mutated. Thus the colour of the eyes, or the hair, might be changed; or the resistance to disease could be diminished. These mutations are quite random, and unpredictable in detail. For example, if the chair in which Queen Victoria was doing her knitting had been shifted one-thousandth of an inch away from its position at one strategic moment, one of her chromosomes would not have been hit by a bullet of cosmic radiation, and the Spanish royal family would not have suffered from the troublesome disease of haemophilia. The incident may be fanciful, but such a mutation did take place, and its effects will dog that issue for a very long time. These mutations, then, are the basic method whereby evolution takes place. But here is the difficulty—our human bodies are so astonishingly complex that they must have required thousands (probably millions) of mutations to bring them to their present condition. Some of these, such as those that led to the development of the eye, are not immediately useful, and they only acquired survival value when supplemented by other subsequent mutations. There simply hasn't been long enough for all these mutations to occur. We can soon see this if we realize that the human race has been in existence for about a million years. If we take twenty years for one generation this involved 50,000 generations. This is nothing like enough for the changes that are needed, since we have no reason to suppose that a new valuable mutation occurs more than once in many generations. In olden times the situation was less favourable than now, for there were far fewer people alive. (It is a sobering thought that if you were to add together all the human beings that have ever lived on this earth, you would find that one in twenty-one of them all was alive today!) So we should have expected a very vast length of time for the evolving of the human race. But in fact there are some grounds for the belief that most of the later changes have taken place in the last 10,000 years. Some geneticists are being driven to talk about co-operative mutations in which one mutation is supposed to make the next mutation easier. This is dangerously near a view of some kind of *élan vitale*, or teleological interpretation of biological study. It is therefore anathema to most biologists (and if they *could* remain strictly biologists, rightly so). We are therefore left in an impasse. We believe in evolution although there really doesn't seem to have been time enough for it to operate. There is a great temptation here for the theologian to convert what is essentially a biological problem into a theological one; and it must be resisted. We shall do no good if we come rushing up to the biologist in order to tell him cheerfully that he need not worry about this time scale, since it is really only an indication that God was directing the process, and therefore we don't require

the conventional period of years. If we chatter like that, we must not be surprised if he replies by asking us who would be thought responsible for conventional time periods in biology. There is no answer—God must be seen in the known, the understood, the 'conventional', and not merely in the unconventional which we cannot otherwise understand. And if the biologist can put his questions about evolution in scientific terms, then it must ultimately be in scientific terms that they get their answer. Otherwise it is no answer, the scientist is rejected, and the product of the human mind which God made is being treated as irrelevant to the understanding of God. Here again our Christian belief in the Incarnation should save us. There is value in what the biologist, *qua* biologist, has to tell us about evolution. There is also value in what the writer of Genesis and all those others who in later years have struggled to reveal God's purpose in the world of living things have said. But the purpose of evolution is not to be identified with the mechanism. The cobbler had better stick to his last.

We have now come to the third of my great debates. I posed this in the form of a query: could man be explained solely in terms of his chemical and biological structure? Is his sense of freedom—free will—entirely illusory, a suitable study for the psychologist? Do the facts of science give it such authority of explanation and objectivity that all things subjective have become trivial and without ultimate significance? 'Science', wrote Sigmund Freud at the end of his book on religion, *The Future of an Illusion*, 'is no illusion. But it would be an illusion to suppose that we could get anywhere else what science cannot give us.' That was the way of the late Victorian era with its exuberant self-confidence, and the first Edwardian era with its ignorance of tragedy. It is not the way of the modern scientist. He is more humble now. He ought always to have been humble. For the beginnings of science were associated with the recognition that much of what happens in this world is quite beyond our powers of comprehension. Science began because it learnt how to ask easy questions and was not ashamed to confess its ignorance of more difficult ones. 'The cause of gravity', said Newton, 'I do not pretend to know.' Suffice it for him to study not its cause, but its laws. The 'cause' could perhaps be a theological issue; but if so, it must not be allowed to interrupt his study of the behaviour of solid bodies, whether they were apples in his father's orchard in Lincolnshire, or pebbles falling from the top of Pisa's tower, or planets circling the sun. About the 'cause' of these he could be agnostic. This is the interpretation of his famous *hypotheses non fingo*. But this tradition of humility changed during the nineteenth century. It was partly associated with the popularization of science, so that it was not surprising that so many of the great public debates took place at meetings of the British Association. Even the word 'scientist' is a recent one. The word 'science' is very old, reaching back to Plato and the Greeks; but the word 'scientist' dates only from 1840, the year in which Whewell became President of the British Association, as well as being Master of Trinity, Cambridge. He wanted a word to describe the new species of men—the professionals—who were now doing science, and so he called them scientists. I am sure that it is not accidental that this corresponded with the burst of conceit which infested much popular development and exposition of science. 'Give me matter and motion', said one famous scientist, 'and I'll construct the universe.' Now, matter and motion are

not unimportant constituents of our universe. But few of us would wish all other ingredients to be brusquely excluded. Here is another paragon of modesty: 'Just as the bile is a secretion of the liver, so is the mind a secretion of the brain'—with its inference that everything mental is merely the conduct and result of certain glandular activity, that everything which charms and delights us, whether poetry or love, is as mechanical as the contents of a watch, but presumably without the justification for its existence which is necessary in a watch. It seemed in those days, when professional science was growing, that the whole world was swimming into its net, and that therefore there was no need for any other interpretation. Perhaps this sin of pride was partly the explanation of the violence with which the scientist sometimes tried to smash his opponents; and the debate with Christianity grew most bitter.

But now it is quite different. The modern scientist would hesitate to say anything about free will. He would point out that this was a concept used to co-ordinate the description of the activities of a person. The awareness of free will was personal, entirely incommunicable by direct means to anyone else. It was part of an actor-view of the universe, and it did not, therefore, figure in his scheme of concepts and ideas. He would study atoms and molecules, and he would observe their chemical behaviour. He might even describe the internal working of a body, and eventually be able to trace the set of electrical impulses associated with touch, or sight, from the organ of reception right to the brain; he might ultimately hope to follow these little impulses as they divided themselves among the many tiny electrical circuits of the brain. But this is not a description of touch, or sight; it is a description of the mechanism of touch or sight—which is a very different thing. Free will is not discredited because a scientist says that it does not correspond with any of the concepts which he finds useful in his own work. It could indeed be argued that it would be much more serious if it did!

I wrote a few pages earlier of the sense in which a biologist *qua* biologist might have nothing to say about the teleology involved in an evolutionary scheme, and of the inability of a scientist *qua* scientist to deny or confirm the validity of the concept of free will. But of course a scientist is never nothing but a scientist. He is a human being, who eats a breakfast which may or may not agree with him; he has children, who may or may not be well behaved. The questions that are posed by situations of this kind must be settled outside the range of his pure scientific thinking. If we recognize this, we are saved from wasting time on what Max Planck, the distinguished German theoretical physicist, used to call 'phantom problems'. The conflict between free will and determinism is really no problem at all; it appears to be a problem only because we mix our fields of thinking. Thus free will is associated with my response to given situations. If I am a human being, I am myself aware of having to decide things. People who are not aware of this are usually put in mad-houses, since awareness of decision is one of the criteria by which we decide whether or not a person is really human. No kind of physical, or chemical, theory could conceivably take away from me this sense of decision of free will. But equally well I cannot share my free will with you (except perhaps in circumstances of exceedingly close human relationships, such as a lover and his beloved, or even, more rarely, within the fellowship of the Christian community). If I describe it, you

may understand my description; you will not know my anguish as I try to make up my mind. And even if, after the event, you become a psychologist and try to tell me why I decided in the way I did, that is only a *post-factum* account; it is certainly not the experience of free will. If, in your self-confidence, you should dare to tell me beforehand what I shall decide, I know that, whatever you may say, I am free to do just the opposite. And rightly feeling that you have affronted my dignity as a human being (or child of God), I am very likely to 'prove you wrong'.

There is all the difference in the world between the actor, experiencing in his own self the tumult of decision and anxiety, and the spectator, noticing behaviour, studying the feelings associated with it, and building therefrom an account of me which he calls deterministic. You would need tremendous and detailed knowledge of me if you were to succeed in this deterministic account. But in principle I believe it could be achieved, within limits. Observed from within, the will is free; observed from without, it is determined.

We must now turn to some general considerations about science. Some of them are already involved in our preceding discussion. What really is the status of science? This question is not concerned with technology, whether in the making of gadgets or the exploitation of the ideas and discoveries of science. It is concerned with the claims which a scientist may rightly make for his work. These are quite different now from what they were often supposed to be fifty years or more ago. For then the scientist would have said that he was describing reality; he alone was showing us things as they really are, 'things-in-themselves' —if we may use Kant's phrase. Today, however, he would be more modest. It is true that he would claim to take into his analysis the whole world of human experience—and this means the sense data that we receive, the things that happen to us, the things that we encounter mentally or physically, the world which I see as it meets me, or which I myself go out to meet, the totality of human experience. Nothing less than this belongs to the field of inquiry of the scientist. There is no tree the fruit whereof he must not eat. But what he does with this vast sum of material is not to claim that it reveals things as they fundamentally are; he seeks more modestly to build out of it a pattern. To establish this pattern we select, often with painful simplicity, such elementary situations as lend themselves to a simplifying process. But as our subject develops, the pattern becomes more comprehensive. We only ask of the pattern that it shall be coherent (i.e. have no internal inconsistencies) and meaningful, and capable of growing. We desire also that it shall be attractive, and we believe that for scientific purposes we achieve the pattern by a process of abstraction and generality, and we express it by what is essentially a kind of symbolism.

But these last few sentences deserve—and need—some elaboration. First, the facts. I was brought up to believe that facts alone mattered to the scientist. Let the artist, the poet, the man of religion continue on his way in blissful ignorance of facts. The scientist at any rate knows the solid ground on which his feet are placed. But this is a grievous half-truth. What, for example, could be less interesting—more deadly dull—than a bare fact? If a workman repairing the wall of Lincoln College happens to drop a small brick, it will take a certain number of seconds to reach the ground. How dull! It could be of absolutely no importance unless—as happened to me yesterday on my way to a conference

—I was underneath its line of falling. A stone dropped by Galileo from the Leaning Tower of Pisa takes longer to reach the ground than the Oxford brick, or Newton's famous apple in his Lincolnshire family's home. But that is not science. Science is what we ourselves make of those facts. Someone must breathe the spirit into the bare bones if they are to live. This breath of the spirit is science. There is no sure way of it. Newton could say that no scientific discovery was ever made without a leap of the imagination, and Einstein echoes the thought by asserting that there is absolutely no way by which, starting with the bare facts of observation, you can with certainty pass to the theory which binds them together. Max Planck, who shares with Einstein a very large part of the responsibility for initiating modern physics, wrote of science that it was a creative work of art, for new ideas, he said, are not obtained by any logical deductive process, but by a creative imagination. T. H. Huxley, of whose part in one of the great debates I have already spoken, once uttered these words: 'It is a popular belief that the scientist is under obligation not to go beyond the facts of the case. But those who know are aware that a man who never goes beyond the facts seldom gets even as far as that.' And Pasteur said: 'If you tell me that in talking like this I am going beyond the facts, I shall reply that that is my way of looking at things.'

How different this is from the older view! And how silly it makes much of our recent controversy about the rights and wrongs of a scientific or a humanistic education! If we could come to see science as it is, and not as it used to be thought to be, we should not be afraid of it. The true humanist, said George Surton the historian, should study the life of science as he studies the life of art and history. One of the keys to the understanding of science by the layman ought to be its kinship with the arts. When Professor Dirac of Cambridge, Nobel Prize-winner for his work on the quantum theory, began a course of lectures at the Institute of Advanced Study in Dublin a few years ago, he started with these words: 'The theory which I am going to describe, if it is to be acceptable, must be both neat and beautiful.' This conviction that the universe is mediated to us in terms of pattern, and of beauty, finds expression most clearly of all in the startling work of the modern theoretical physicist. I have recently been thinking about some of the greatest discoveries in this field—such as the theory of relativity, the positive electron, and the Pauli principle for the behaviour of electrons in atoms and molecules—all of them are based essentially on symmetry. This belief in symmetry has been the guiding principle in almost all the work of this kind. Yet far from being unscientific, it has 'delivered the goods', and changed the very world in which we all live. Simone Weil could say that the beautiful was evidence for God. If this is so, the theologian, so far from fighting shy of science, should rejoice in its development.

But there is more to it than this. If beauty and some sense of value play so central a part, then clearly the personal element in science is more significant than we used to suppose. A moment's thought will show that this is indeed true. Among all the thousands of scientists I know, I've never met one who did an experiment just for the fun of it. He did it because he himself had a hunch that it was worth doing. Sir Charles Darwin once said that just once in your life you ought to do 'a damn-fool experiment' (so he blew a trumpet at some tulips!). The very fact that he could write like this is evidence for the sense

of personal conviction, personal hope, personal involvement that beset him round. It was a scientist of great distinction, Professor Polanyi, who entitled his recent Gifford Lectures *Personal Knowledge*. It is because there are human beings, with human frailties and human imagination, that science is possible. In this sense science is deeply personal. The scientist may have his feet firmly grounded on the solid earth, where the dull meaningless acts are to be gathered up; but his head is among the clouds.

If we can come to accept this personal character in science, then we shall come to see also its essential humility. The astronomer Pepler may have been right to fall on his knees in an ecstasy of wonder, praising God that he could think God's thoughts after Him; but these thoughts come through human minds, with human limitations. There is an austerity and a grandeur in science of which our generation has every reason to be proud. But the vessel in which this grandeur rests is an earthen vessel. None of us has any right ever to suppose that his work is final, or that it proves anything at all; for there is always that which J. R. Oppenheimer calls the 'element of unexpected novelty' about things. It is one of the paradoxes that though the great scientific developments of the last fifty years represent a tremendous success, and a mental achievements that is at least the equal of the magical 250 years of Ancient Greece, yet they have, and must always have, about them the character of an unfinished story. Even the elements in this story have a kind of make-believe about them. For the scientist, having abandoned the impossible attempt to know things-as-they-are, now recognizes that he speaks in symbols. These symbols are the concepts by which he builds his meaningful coherent pattern. They are symbols and not materialistic truth, because it is their function to mediate truth to us. This they do in so far as their behaviour corresponds with what we observe. I have myself spent some thirty years studying the electron, and have written many articles and books about it. I realize its importance in understanding the telephone, the electric light switch and the TV tube. It is a central concept in modern physics. But I do not know whether there really is an electron! Yet in some strange sense, as I grapple with it, write down its equations and study its behaviour in different circumstances, it seems as if I am grappling not with a difficult concept which is in danger of becoming too unruly for me, but with some reality, deeper and more lasting than my concept, yet mediated to me in deeply personal terms by concepts just like this. I cannot hope to describe this reality any more than the artist can force his brush to put on to the canvas the reality with which he grapples. We accept this for the artist, why should we hesitate for the scientist?

These changes in our understanding of science and the claims that we make for it ought to encourage us, for they show that science is indeed one of the languages in which God is to be described—incomplete and needing the support which other languages can give. It was Werner Heisenberg, the most distinguished living German physicist, who wrote, in a book published last year, that 'modern science is a specifically Christian form of Godlessness'. He was thinking of the imagination, the rigour and discipline of thought which are needed, the value judgements as to what is beautiful and satisfying, the aesthetic, artistic, even spiritual quality in science. And his words should give us pause. For they show us that in this curious transforming power we have something not utterly alien, nor of which we should feel afraid. There will be puzzles; there will be

great debates in our time similiar to those three of which I spoke earlier. This means that we need to think, and to think charitably and imaginatively. Theologians have not always played fair with science, nor have scientists always played fair with theology. But there is a new spirit abroad today. And if we really believe that the psalmist was right to cry that the 'earth is the Lord's, and all they that dwell therein', then we may even come to the place where we see that the scientist may be one of the messengers of God.

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