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THE PRESUPPOSITIONS OF SCIENCE: A SYMPOSIUM

By

J. N. HAWTHORNE, B.Sc., Ph.D.

AND

R. E. D. CLARK, M.A., Ph.D.

THE VICTORIA INSTITUTE

22 DINGWALL ROAD, CROYDON, SURREY

THE PRESUPPOSITIONS OF SCIENCE

I

By J. N. HAWTHORNE, B.Sc., PH.D.

BEFORE opening the discussion on " The Presuppositions of Science " I think I ought to define " science " as I am going to deal with it here. I have taken science to mean natural philosophy in the old sense: the study of nature by observation, and by the inducing of generalizations, which we call scientific laws, from those observations. I do not think that anything is immune from such treatment. The method of science can be applied to any subject, though with more success to some than to others. For instance, if you describe a Beethoven symphony in scientific terms of frequencies and overtones, you get a complete description in one sense, but many people would think that it had missed the whole point of the music. So that is the way in which I have taken " science ", and this Natural Philosophy will cover physics, chemistry, biology, pyschology and so forth.

Now my first presupposition is that Nature is orderly: that it is uniform. I think this is the basic presupposition. If the universe were chaos then there could be no science. The interesting thing is that though we often find exceptions to our laws when we study phenomena more carefully, we do not give up at that point and assume that the laws were delusions, that things are not orderly, after all. We assume that Nature is orderly and we look for a new and more general law. But it is difficult to prove this supposition that Nature behaves in an orderly way.

One example comes from the study of radioactivity. If you take a sufficiently large group of radio-active phosphorus atoms, for instance, half of the atoms will have decomposed within fourteen days. If we take any particular atom, though, we cannot say when it will decompose. There is no law to help us here. We could say, then, that there are three possibilities: (1) that the decomposition of radio-active phosphorus atoms obeys no law; (2) that the atoms have minds of their own, or something equivalent, so that they decompose when they want to; (3) that there *are* laws governing the phenomenon, but scientists cannot yet tell us anything about the forces involved. Falling back on the regularity presupposition, the idea that Nature is uniform, we take the third viewpoint.

It is interesting that this uniformity presupposition does come in quite often in the arguments of scientists. For instance, there has been a lot of discussion on the subject of parapsychology. The phenomena studied by people like J. B. Rhine do not seem to fit in with our present scientific ideas and a very bitter attack on their findings has recently been published in *Science*[1]. The basis of that attack on parapsychology is merely that it does not fit in with our idea of Nature's orderly behaviour,

[1] *Science*, **122**, 359 (1955).

and would upset some of our present scientific laws. It seems to me that this is rather an unreasonable view. If fuller observation establishes the results our present science will have to be modified considerably. The Greeks were great thinkers, yet their science collapsed after more than a thousand years! Because our studies seem to have been " of a piece " since the sixteenth century we need not assume that they will remain so indefinitely.

One final general point about the uniformity presupposition. Science as we know it today had its origin in the work of men like Bacon in the seventeenth century. If you look at the lives of some of the early members of the Royal Society, of Bacon and his contemporaries, people who were most interested in the study of Nature, you generally find that they had a very definite Christian faith. They felt that they were studying the handiwork of God, and they expected Nature to be orderly, and to be worth studying: and that was the incentive for their scientific work. It is rather ironical that the same science which is still using their methods has sometimes been used, more recently, to attack the Christian position.

Extending this uniformity presupposition, scientists say that things have behaved up to the moment in an orderly way in the universe and that they will *go on* behaving in that way. We have dropped the apple ninety-nine times and it always fell; therefore it will fall in the same way when we drop it for the hundredth time. We extend all our scientific laws into the future, and back into the past as well. Several of the findings of the physicists suggest that the universe had an origin at some point. Entropy, which seems to be increasing, points not only to a definite beginning, but in addition points to the eventual " heat-death "of the universe, as I think Sir James Jeans calls it, in which everything reaches a sort of lukewarm position! These ideas of a beginning, with its implied discontinuity, seem to be repugnant to physicists, and various theories have been put forward to overcome the difficulty. For instance, Gamow and other scientists have suggested a cyclic universe which runs down and winds up again, so continuing indefinitely. That gets us over the beginning and ending difficulty; and, in one sense, keeps the universe running, keeps it uniform. Yet in another sense it dispenses with the uniformity principle. It would involve, for instance, a reversal of the law of entropy every few billion years, but if we have got to assume this then we have thrown away the uniformity presupposition! In a similar way there is the cosmological theory of Hoyle at Cambridge in which matter is being continuously created and destroyed, so that the universe goes on for ever. It has no beginning, and no end. If one understands Hoyle's book correctly, he says that matter is created from nothing. This again dispenses with one of our laws—the conservation of mass-energy. Moreover, we have never observed this! If we are to believe that, something has had to go in order to try and preserve the overall uniformity of the universe.

One final thought. Some philosophers might argue than man's own liking for order is responsible for the apparent order in the world of science, that it is only a reflection of his own tidy mind. Yet even they admit order in one part of the universe—man's mind—so why not say that the order scientists discover is the reflection of another and greater mind?

My second presupposition is that scientific observation is trustworthy. First of all, we assume that there is a universe outside our own minds which we can know objectively; secondly, we assume that science conveys the whole truth about the universe: not, necessarily, that it has yet done so, but that it will do so eventually.

There has been a lot of discussion among philosophers as to whether anything exists outside a man's own mind: the views of Bishop Berkeley and the idealist School are well known. Science in its present view of the universe tends towards this. Compare the results of physicists to-day with the findings of physicists of thirty to forty years ago, and you will see the great change in outlook. In the old days they were confident that they were describing a real world. Pictures were given of the working of it, and it was described in terms which anyone could visualize—solid atoms in vigorous movement, electrical forces obeying mathematical laws, and radiation travelling in waves through a sea of ether. Today it almost seems as if we have given up the attempt to understand the universe outside our minds. Atoms became first planetary systems of electrical particles, then probability waves, and gravitational forces became irregularities in a space-time continuum. No longer was it possible to visualize reality. When one experiment revealed light as a wave motion, and a second showed it to be a stream of photons, the physicists expressed both results in one mathematical equation, and left reality there. But I am not a mathematician, and I really find myself a long way from reality! So, many physicists say that scientists must not claim that they are studying reality, when they are merely correlating their observations; whether those observations are connected with an underlying reality is another question. In spite of this, the ordinary working scientist, when he does an experiment, makes the presupposition that it will tell him something about reality, and about the world outside his experiment.

The second sub-division of this presupposition (about science telling us the whole truth) has, I think, given rise to a lot of difficulty. For instance, the schoolboy who finds no mention of God in his science textbooks and who has been told that however good a microscope or a telescope may be, he will never be able to find the Creator with it, has assumed that science ought to be able to tell us everything about the universe: that it can give us the whole picture. This is a wrong assumption.

I want just to deal with a point about the mind, as an illustration of the tendency of scientists to present their results as if they were the whole story—to " explain things away " in fact. The argument runs as follows.

First of all, brain activity is accompanied by detectable electrical changes: you can detect the electrical changes, and measure them, when, for instance, a man is thinking, or when he is asleep, or when he has taken drugs. We know that mental activity is accompanied by electrical changes. Secondly, we know that complex electronic calculating machines can do a lot of the things that a human mind can do. Therefore it can be concluded that thought is merely very complex electrical activity in the brain and that there is no such thing as " mind ". It is merely a *subjective* feeling. Again they describe sexual love, for instance, in terms of hormones, as a chemical phenomenon; or they describe fear in terms of adrenaline secretion. They are claiming to describe the whole arrangement of the mind, whereas in fact they are only discussing one aspect of it. It is, in a sense, a complete picture; but in another sense it is far from being the whole story. I think this is rather a dangerous presupposition which we, as scientists, sometimes make: that science is showing us the whole of reality, whereas generally it is only giving us one aspect of it.

Moreover, if science can convey the whole of reality, it ought to be possible to deduce a morality from scientific observations alone; but there have been no very satisfying attempts to do this. From evolution, for instance, as far as I know, it has never been done, without at some point begging the question. You can get a sort of ethic from evolution by saying that the things which survive are the desirable things: those things which tend towards the survival of the human race are ethically good. But always to do this sort of thing you have got to make an assumption somewhere. For instance, in this case you decide, to begin with, that the human race ought to survive—that that is a good thing. It seems to me that science unaided can never give us an ethical standard: we need some other source.

Now the final point I want to make, the final presupposition, is that the human mind is trustworthy. There is no reason to suppose from the scientific point of view that the universe was created by an intelligent being. From science itself we cannot prove that. We can only say that the universe is. In a similar way life's first appearance on the earth can only be regarded as an immensely improbable accident. The same thing therefore applies to man's mind, the latest result of purely physical interactions. If this is so, why should our minds be reliable—how can we use them to deduce scientific or any other sort of truth? The same difficulty has been expressed by Haldane in the essay *Possible Worlds*: " If my mental processes are determined solely by the motions of atoms in my brain, I have no reason to suppose that my beliefs are true . . . and hence I have no reason for supposing my brain to be composed of atoms." A recent attempt to defend the trustworthiness of our minds has been made by Mrs. M. Knight.[1] She says this: " Someone asks us how many cats there are on the hearthrug. We look and say that there are two.

[1] *Penguin Science News*, **25**, 1952 (p. 97).

What happens, in physiological terms, is that images are formed on the retinae of our eyes, electro-chemical impulses are transmitted along the optic nerves to the visual areas of the brain, and so on: and as a result of this we see two cats, and form the related belief that two cats are in fact there." She claims that the belief arises from purely material antecedents but she makes quite a few presuppositions. She talks about electrical impulses: that idea was only arrived at by a long train of human thinking, which assumes that the thought was reliable. We have got to have a conception of what a cat is, gained from previous experience. So the decision that we see cats depends on our memory. The conception of " two " is similarly dependent on previous experiences in which identical objects were seen: we had to be taught that one and one make two. Every link in this chain is not a material one.

In another place Mrs. Knight says in effect: " If electronic calculating machines are reliable, why not the brain, which is the same type of thing? Surely it will give us the right answer." It seems to me that it all depends on how the calculating machine is made. The ones in common use are made by men who understand mathematics and are made to give the right answer! It is quite possible, presumably, to make calculating machines that always give the wrong answers. A machine made by shaking together the various components until they came into some working arrangement, which is roughly the materialist view of man's mind, would very often be the " wrong answer " type! I think that Mrs. Knight's defence of this presupposition does not really stand a careful scrutiny. It seems to me that if we are to assume validity of thought it is much easier to do so from the Christian position, than from the atheistic or agnostic position.

The calculating machine analogy, which has often been used to show that human minds are merely subjective impressions gained from brains working in a purely electro-chemical way, thus turns out to be a dangerous weapon for the materialist. If our minds are to be trusted, it is better to think of them as having been designed by Someone who knew the right answers and made them accordingly, whatever the method used. The argument becomes similar to the one in which our minds are reflections of an Eternal Mind who has made " all things well ".

II

By R. E. D. Clark, M.A., Ph.D.

Dr. Hawthorne has given us a very able and clear exposition of the more commonly discussed presuppositions of science. I do not want to attempt to go over the ground again, since it has been fairly comprehensively covered. He has told us that the main presuppositions of science are three in number—firstly, the orderliness of nature; secondly, some sort of causality (the word may seem objectionable in view of the

recent developments in physics, and Martin Johnson has suggested that we might replace it by "intelligibility"); and thirdly, the trustworthiness of human reason and of scientific observation. Dr. Hawthorne has reminded us that presuppositions have theological foundations; and on this point I should like to make a few additional comments.

Modern science developed from theological presuppositions. In this connection a book which appeared quite recently—Smethurst's *Modern Science and Christian Beliefs*—contains an excellent summary of the views of those who have studied in this field. The following are a few of the points of which Smethurst reminds us. Descartes, after much thought, decided that the only reason why we should think that a clear and distinct idea is true (or has a good chance of being true) is a theological one: God is not a deceiver; God would not have given me a mind in order to lead me astray. Descartes has been much criticized, but nobody has ever suggested a satisfactory alternative to his view; and it is most noteworthy that the modern philosophies of Marxism, Logical Positivism and Freudianism—all of which deny God's existence—are led in the end to doubt the reliability of human reason. Similarly the idea of orderliness, or intelligibility, arises *only* if we believe in a God who is the author of the universe. Smethurst reminds us of the Trojan war in Homer, the deities of each side trying to tamper with the forces of nature in order that their own side might win. We might well picture the universe as being like that but for monotheism. Similarly, primitive peoples do not assume that the seasons will come round automatically; they perform unending rites to ensure that this will happen. Science cannot develop in this mental atmosphere since its presuppositions are denied.

It is a tacit assumption of science that matter is itself worthy of study. Because they did not believe this to be true the devotees of Eastern religions were never able to initiate science. For Eastern religions matter is bad, and you have to emancipate yourself from it. Even in Buddhism, the best of these religions, you have to detach yourself from material things to live the good life. It is the Christian dogma of creation, repeated again and again in Genesis 1, where we read that God made everything and saw that it was good, which makes science possible. Christians hold that matter is good and holy enough to have been the dwelling-place of God Himself. The Christian believes that God has lavished His thought and care upon a material universe. No wonder if Christians think, therefore, that the devotion, the care, the patience and the thoughtfulness necessary for the development of science are worth while. Christianity itself—or at least monotheism—is the really basic presupposition of science, and its historical development shows this to be so. Non-Christians may enjoy the Christian scientific heritage today, but it is not theirs by right. There is much more to be said, of course, but time forbids.

What I am going to say next is really a matter of crossing the t's and putting in the full stops to what Dr. Hawthorne has said, and although I

shall be raising one or two new points, only one of them is, I think, as fundamental as those which have already been raised.

Let us start again at the beginning. Science, I take it, is concerned to find out about the material universe. Why must we make presuppositions to do this? An analogy will be helpful. Suppose you want to find out what is in Joanna Southcott's box; then a little thought will show that, consciously or unconsciously, you will have to make certain presuppositions in order to carry out your task. You must assume, for instance, that the box is the right box. (There are a great many rival boxes, or used to be in the days when Joanna was in the news.) Likewise in science you have to assume that the universe is not there to deceive you. Again, you must assume when you open the box (or X-ray it, if you like) that the things in it will not mysteriously disappear. Similarly, in science you must assume that nature is not magical, that you can get at the truth in the end.

This analogy helps us to understand how the presuppositions of science develop. But now another point arises. Sometimes presuppositions settle down to dogmatic form: to make your trouble worth while you have to assert rather firmly that, shall we say, immediately the box is opened, the things in it won't disappear. At other times presuppositions do not quite settle down to dogmatic form, but they get very near it. You never could be *quite* sure that a given box was Joanna's own genuine legacy to our nation: it was safer to open all the Joanna boxes you could find.

Let us consider, first of all, an example in which a presupposition almost, but not quite leads to a dogma. One of the practical presuppositions of science is that we may only find out knowledge in certain ways. The chosen ways are the way of observation, employing the messages which come through the sense organs, and the way of experiment. It is presupposed that we shall not take any notice of the other possible ways in which information might come to us. Mankind is familiar with many other possible ways of obtaining knowledge—augury, intuition, dreams, telepathy, messages from spirits, prayer, and so on. But these are never referred to in scientific journals.

Now we know that, in fact, a great many scientific discoveries have come through these other ways. Goodyear dreams that if you put sulphur into rubber you will take away the stickiness. He does it the next day, and discovers the wonderfully useful properties of rubber which make motor tyres and other articles possible. Kebulé dreams of atoms gambolling before his eyes, and develops his structure theory of organic chemistry; he dreams again, this time of strings of atoms like snakes eating their own tails, and founds his theory of the structure of benzene which still holds us in good stead to-day.

We may be sure that the materialist would *like* to say that all scientific knowledge must come by the scientific method. But he just cannot say quite that, because he knows it is not true; knowledge *does* come in other ways. But when you write your scientific paper you pretend it does not;

you hide the real source of the knowledge. So what some people would like to develop into a dogma, just fails to do so.

Very often, however, real dogmas of science do develop. Now we do not, as a rule, like to talk of dogmas in science, so it is worth while comparing scientific dogma with Christian dogma. Ordinary simple Christians live their lives without worrying over much about creeds. Nevertheless, creeds are a formulation of the way in which the Christian life is lived. In the same way the scientist gets along very well without thinking of dogmas, without thinking in terms of any scientific creed, and would probably be horrified to see one put into shape. Nevertheless, an outsider watching the way he does his experiments might very well construct a creed for him. And if he were to do so, I think the result might be something like this:

> " I believe in the absolute difference between truth and error, and that it is man's duty to discover and accept truth."

Note that truth, error and duty enter here. They are not, in themselves, scientific ideas, and no science can verify their existence. To continue:

> " I believe that knowledge is better than ignorance, and truth than error."

We note the scale of values. Again, the idea that one thing is *better than* another cannot be discovered or verified by science.

> " I find myself placed in a universe the truth about which it is my duty to discover. This universe influences me by reacting upon my sense organs, and I believe the impressions I receive are meaningful and significant. What I call the universe is not a hoax, or a nightmare, and I am in duty bound to take it seriously."

We are only too familiar with hoaxes and nightmares, but we do not take them seriously, and we have to assume that the other half of our existence corresponds with something we must take seriously.

> " Though I cannot directly compare my own sense impressions with those of other people, I believe, nevertheless, that other people have experiences similar to mine."

Again I have to make this assumption, or else science could not develop. I could not, and would not, attempt to communicate ideas to other people without this presupposition.

> " I believe that the human mind is so constituted that it can understand the universe."

Notice, we specify here the " human mind ". (There are plenty of other minds, the minds of animals, and so on, but we make no assumption about them.) The word " understand " calls for further discussion, but I forbear.

> " I believe in the unity of nature, and of all natural events; and since I accept this unity, I believe that all natural events are potentially observable."

If there were two natures, with no interconnections at all, nature would not be a unity.

> " In seeking to understand nature, I presuppose four axioms: Firstly, that order is not self-creating, but must be explained as the result of pre-existing order, the arm of coincidence not being very long.
>
> " Secondly, and arising from this, the law of cause and effect statistically interpreted.
>
> " Thirdly, that nature is fundamentally simple.
>
> " Fourthly, that the elegance and beauty of theories is in some way connected with their truth."

There is much here that calls for comment, but I must content myself with stressing the first two axioms, which may be summarized by the statement that order is not self-creating.

This is, perhaps, the most basic of all the presuppositions of science. It is the one, in fact, which Descartes proposed as the foundation stone upon which science should be built, the basic concept which made him and still makes us moderns part company with Aristotle and the ancients. For Aristotle the final cause—for remember that his imaginary self-ordering forces were purposeful—was contained *within* matter. Matter for Aristotle was divine or semi-divine. But to-day we no longer hold this view, and modern science could never have developed were it not for its overthrow.

But oddly enough, this presupposition seems to have come under a cloud, judging by the rarity with which it is mentioned. Not that it altogether escapes attention—one does very occasionally see it referred to. For example: P. W. Bridgman (the " high pressure physicist "; if I may respectfully so call him) says in his book *The Nature of Thermodynamics:* " It is strange that we do not seem to require any explanation for the tendency of a system of many members to increase in the disorder of its arrangements." In other words, he says, we watch nature at work, but we only ask, " Why did that happen? " when we see an order, some sort of non-chance arrangement in time and space, coming into existence. If no such order arises, or if the order disappears, we assume that we need ask no questions.

This is a remarkable assumption to make, but it is one which we make almost unconsciously. Here are a few examples:

Our ancestors were exceedingly interested in what they called the *lusus naturae*—the game or freak of nature. They used to collect stones which they picked up in mountain districts on which they thought they could see the delineation of a human face, a giraffe, or some other object. We are not interested in the *lusus naturae* today. I do not suppose that a

single modern scientific paper has been published on why we get these curious shapes. We attribute them to chance and nothing more. If we thought there was something other than chance, we should try to explain them.

But the scientist would then argue that, odd as they are, they only arise as the result of a *falling* from some other ordered state. In other words, what appears to be the production of order is *really* the production of disorder! And about that no scientific questions need be asked.

Once again, we watch the formation of crystals and explain the new order by saying that it is the result of the shapes and other properties of the molecules. Similarly we assume that the X-ray diagram of a crystal corresponds to the atoms in the crystal. We are not prepared to assume that the shape of the crystal, or the X-ray diagram of it, comes into existence by chance.

People have been worrying their heads for a long time as to why it is that gamboge particles, certain cocci, etc., arrange themselves under the microscope into pearl strings. Is there some subtle unknown force which turns them into those long necklaces? A paper in *Nature* (Fessler, **177**, 439) recently argued that the formations are random; we should not ask any more questions about them. Glass beads thrown on glass behave in the same way—though randomness is not the only factor, for the human eye tends to join points together, obscuring slight differences in the distances between them. And if the formations arise by chance, we need not ask *why* they arise.

In his recent Halley lecture to the Royal Society, Ryle argues that since the extended source radio stars are found in the plane of our galaxy, they therefore belong to the galaxy. Similarly since the point source radio stars are distributed at random so far as their direction is concerned, they must belong to other galaxies. Here it is assumed that the order observed did not arise of itself, as we should have to suppose that it did if the universe as a whole had provided radio stars only in the galactic plane, or conversely, that our disc-shaped galaxy had provided radio stars distributed at random in space. In either case it is assumed that the order is *not* the result of coincidence—if real coincidence was involved scientific questions would not arise. We simply do not bother to investigate real coincidence. Once you have convinced yourself that something is the result of chance it is not worth investigating further.

This is a basic presupposition of science, and, theologically, it is rather interesting. For it is at this point that the sceptic often tries to challenge the Christian, particularly in connection with origins. Once you ascribe the origin of the universe, the beginnings of life, or progress in the complexity of life on our planet, to chance, nothing more needs to be said. And this is what the sceptic tries to do. He tells us that the universe winds itself up by a freak in infinite time; that primeval slime produces, by

chance, a speck of living protoplasm, and that natural selection does the rest. And after that, there is no more to be said.

In these ways facts which seem to call aloud for explanation are classified with facts for which no explanation is commonly sought. This facile procedure can hardly fail to arouse suspicion, because it assumes that in all *lesser* respects science is right in its presupposition that ordered systems become more disordered, but that in its *greater* aspects you are at liberty to invoke coincidence.

Scientifically, you explain all manner of instances of order by saying that still greater order produced what you see. You argue backwards in time until you come to the greatest conceivable order. How did that arise? By coincidence; therefore it needs no explanation! Such a view, surely, knocks the bottom out of science. If coincidence can account for origins it can account also, with far greater ease, for *all* subsequent examples of the production of order. And that being so, we need ask no questions about nature. This position, logically, would appear to be the inevitable ultimate standpoint which we must take if we disbelieve in God. So once again, as if by a circle, we finish up with the position with which we started—the basic presupposition of all science is a belief in one God.

Finally, let me emphasize again that these comments are not intended to be a complete account of our subject. All I have done is to make a few scattered comments which may prove helpful in discussion.

III

Discussion

The Chairman (Dr. R. J. C. Harris) summarized the points made by the two speakers. With reference to Dr. Clark's contention that there had never been any successfully developed science outside a monotheistic culture, he asked: " What about the Chinese? "

Dr. Clark said: I am no authority on Chinese science, but I always imagined that the Chinese, though expert in technological developments of a simple kind, made very little headway with science.

Mr. G. E. Barnes said: As generally used, the word " presupposition " seems to have two meanings. It may mean a belief for which there is no logical justification (it may not on that account be untrue, however), or it may mean a proposition (whether logically justifiable or not) which is essential to a particular intellectual exercise. Now as science is an intellectual exercise, and not a person who can hold a belief, it seems to me that the phrase " presuppositions of science " must have the second of the two meanings, i.e., assumptions without which there could be no science.

Much of what we have heard to-night, however, deals with presuppositions of scientists rather than presuppositions of science; and I suggest it is most important to distinguish between the two. One scientist will approach his work with all the presuppositions implicit in a materialistic world-view, while another will start with the preconceptions of a Christian theist; and yet both may be competent scientists, and use the same scientific method, which is independent of most of their presuppositions. Of course, it may be that some philosophical presuppositions more readily predispose toward the development of science than others. Thus a realist is more likely to become a scientist than is a subjective idealist; and historically it was Christianity rather than Animism or Buddhism which fostered the growth of science. But the fact that to-day the ranks of scientists include those who are neither Christians nor realists shows that such presuppositions are merely predisposing, and not causal, factors.

Dr. Hawthorne's second presupposition (p. 66, para 2) is a case in point. It is true that earlier scientists assumed that there is " a universe outside our own minds", and that to-day " the ordinary working scientist, when he does an experiment, makes the presupposition that it will tell him something about reality ", but this presupposition is not essential to the scientific method. As Eddington has pointed out (" The Domain of Physical Science " in *Science, Religion, and Reality*, 1925), science is a closed system which logically need bear no relation to reality at all. The second part of this presupposition, " that science conveys the whole truth about the universe ", is similarly, as Dr. Hawthorne shows, a presupposition of certain scientists, and not a presupposition of science. The same applies to much of Dr. Clark's paper, including items 1, 2, 3, 4, 5, and 6b, of his " scientist's creed ".

Another matter I should like to comment on is the use of the concepts of order and uniformity. Both speakers appear to equate " order " and " uniformity ", and to regard both as presuppositions of science. I should like to suggest, however, that the order in many natural events can be observed by the senses, and that therefore the order in nature is an empirical fact, and not a presupposition of science. Now there may be more than one type of order; and, in fact, man has from time immemorial recognized two types, teleological order and causal order. Until science developed, the causal order was recognized only in simple situations (e.g., when a hammer drives a nail into a piece of wood), but what science did was to extend the causal order to embrace all objects and events in the universe. To do this it ignored other possible types of order and presupposed that the causal order was uniform. The presupposition of science, then, is not that there is order in nature, but that that type of order which we call causal is uniform.

I am not very happy about Dr. Clark's statement that if we observe order disappearing we ask no questions about it (foot of p. 72). That may be true of physicists and chemists—I do not know—but it is not true of biologists, who explain catabolic processes in terms of enzyme activity, or the decomposition of dead organisms in terms of bacterial action. But, of course, I agree that we always ask questions about apparent increase in order.

Lastly, Dr. Hawthorne's third presupposition, the validity of human thought, is not confined to science. It is necessarily a presupposition of all intellectual disciplines.

Mr. A. K. WEAVER said: I am not satisfied that the presupposition of " uniformity " is really essential. It is sufficient for the scientist to suppose that nature is *usually* uniform. This distinction is most important because it allows room for miracle. Perhaps this is best seen by a homely illustration. British Railways operate a regular train service according to the time-table; this is clearly for the benefit of the passengers. But occasionally this uniformity is disturbed, for example, by a special train put on for royalty. May we not say that God " operates " natural processes in a uniform manner for our sakes, so that we may live orderly and rational lives? But on rare occasions a special train is put on for some special purpose, and we call this a miracle. If he only makes the presupposition that nature is *usually* uniform, the scientist has no difficulty in including miracles in his scheme. The term " usually " must mean, of course, a very high percentage of occasions.

The CHAIRMAN, summing up the discussion, then said: I should like on your behalf to thank Dr. Hawthorne and Dr. Clark for their stimulating papers. We have had an interesting discussion and clarified our views. There seems to be one presupposition on which we are all agreed—to quote Mr. Barnes's phrase—" that that type of order which we call causal is uniform ". So far as the other presuppositions mentioned are concerned, we are not so sure that these are not derivative. We are sure, however, that the function of the scientist is to observe and to construct a system that can be tested empirically. The chief requirement here is not simply that the scientist should have the *correct* philosophical attitude but—more important than ever to-day—that he should realize the necessity for complete personal integrity.

IV

AUTHORS' REPLIES

Dr. HAWTHORNE said: I agree with Mr. Barnes that the presupposition that there is a universe outside our own minds could be dispensed with, but the science which did without it would no longer be natural philosophy —the study of nature. It would merely be an intellectual exercise bearing

no relation to reality. I feel sure that very few people who really believed that would spend their lives in scientific research. It would be difficult to take a scientist seriously if he continually reminded you that his results did not really tell you anything about the world, only something about his own mind. With regard to the third presupposition, I cannot think less of it because it is universal.

Mr. Weaver's " usually uniform " nature raises more problems than it solves, I feel. In my own view miracles are not the suspension of orderliness but the introduction of a new factor by God. A nature which was occasionally non-orderly would not be uniform in the sense which our science requires—it would not be predictable. A clock which is only " usually " reliable would not be a reliable clock at all. The scientist must have a uniform nature for his work. When he comes to study miracles (which would only be noticed if nature were otherwise uniform), he can only look at the historical evidence with an open mind and ask what higher order might have been brought in, if he sees no other explanation.

Dr. CLARK said: With Mr. Weaver's position I am, in the main, in agreement. It is enough to believe that causal laws are *usually* uniform, and empirical evidence can tell us no more than this. But I hesitate to say that God works miracles by suspending laws—perhaps He does, but how do we know? Elijah went up into heaven: did God provide a force greater than gravitation which lifted him, or did He stop the force of gravity? Again, how can we know?

Mr. Barnes attempts to reduce the bulk of what Dr. Hawthorne and I have said to irrelevancy. May I consider his criticisms a little more fully?

His curiously restricted notion as to what constitutes a presupposition gains little support from dictionary definitions. " To assume . . . to require as a necessary preliminary or antecedent . . ." (Wyld)—such a definition includes what he dismisses as " merely predisposing and not causal factors." (According to the O.E.D. it is correct to speak of a democracy as a presupposition of a monarchy if you suppose that monarchies are only thrown up by democracies, but there is no suggestion here that this is an inevitable trend of events. The distinction between " merely predisposing " and " causal " factors counts for little in history and psychology.)

The notion that science is " an intellectual exercise " is similarly restricted. Science stands also for a great historical movement. Why ignore " a necessary preliminary or antecedent " to this movement? To argue that monotheism is not a presupposition of science because the ranks of scientists *now* contain those who are not Christians is like arguing that men are not necessarily born of women because some men *now* have no

mothers. If we let Mr. Barnes have his way, there will be no presuppositions of science left to discuss—the only one he seems to recognize is not a presupposition at all in Mr. Barnes's sense. You no more have to assume that causal order is uniform in order to discover scientific laws than you have to assume the non-existence of royal trains or railway accidents in order to compile a railway timetable.

To distinguish between the presuppositions of science and the presuppositions of scientists is, I suppose, impossible. Does not this imply that the " intellectual exercise " we call science can take place other than in people's minds? The presuppositions of science are, surely, the " necessary preliminary or antecedent " factors which make the intellectual exercise possible—the beliefs which break down man's laziness, which give him a sense of worthwhileness in his quest, and so on.

The point of the reference to Eddington escapes me. Eddington, we are told, said that science has " logically . . . no relation to reality ". But this only confirms what Dr. Hawthorne said. It is a presupposition that this relation exists: it is *not* logical. This, I suppose, was Eddington's view, though he is admittedly a difficult writer. In the place referred to he implies that physical science, though logically a closed system, is nevertheless related to reality in an unknown way: " actual phenomena are more limited in variety than imaginable phenomena " (p. 204). Does not this mean that you could have a thousand " sciences ", each of them logically a closed system, yet only one of them would be " right "?

Mr. Barnes's point about the decomposition of dead bodies (he might have added radioactive decay or the fading of photographs as examples of a physical kind) is a useful one. I suspect, however, that what attracts our attention is not the disappearance of order as such, but the *ordered* disappearance of order. The order that once was is replaced by an ordered sequence of events; it is this *new order* that is explained in terms of enzymes, bacteria or whatever it may be.

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