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SCIENTIFIC THOUGHT IN THE COMING DECADES

WHAT are likely to be the main developments in scientific thought during the second half of this century, and how will they influence social trends?

There is no doubt of the importance of this question in making any estimate of the social outlook for the coming period. During the last hundred years exact science, based ultimately on Newtonian principles, has been the greatest single influence affecting the development of society, and this influence has been exerted not only directly through its technological applications, but also indirectly through its effect on thought in general. The influence of science on general methods of thought, for example on ethical, social and political conceptions, is subtler and more elusive than the effect of technology on industry and warfare. Yet in certain periods the impact of new scientific ideas and principles may be as important as that of new inventions, and in this survey it will be assumed that this will be true in the coming decades. The argument will suggest that the practical discovery of the atomic bomb will be followed by theoretical discoveries of equal social importance.

At first sight it may be considered fantastic to attempt to anticipate the future of scientific thought. It is often considered that prophecy of such a kind cannot constitute anything more than an arbitrary personal guess, so weighted with the probability of error as to be of no practical value. Yet this need not always be so. The history of science shows that the general character of new theoretical developments has often been anticipated years or even decades before they received their definitive expression or their decisive experimental confirmation. This was true in respect of both Newton's formulation of the law of gravity and Darwin's theory of evolution by natural selection. And it is not surprising. It is often much easier to sense what is in the air than to achieve its precise constructive formulation, and the more important the issue the more likely it is to be the case. Thus we

find that there were periods when the scientific world seems, at least in retrospect, to have been waiting for a definite step which many knew to be necessary but none could yet achieve. At such times it often happens that speculative philosophers, mathematicians, and others are occupied in preparing the ideas which will subsequently be applied by the scientist.

The outline of the future of scientific thought which is put forward here is based on the view that we are now in one of these anticipatory periods. A study of scientific thought, particularly in physics and biology, during the first half of this century reveals certain latent trends which are not yet fully explicit, but may mature in the new theories of the coming period.

So much in provisional explanation of this speculative attempt; its final justification will be given or withheld by the actual course of events. But it must be made clear that two further assumptions underlie these predictions: (1) that the continuity and vigour of science is not prejudiced by economic decline, State influence, or by war—on this I express no view; and (2) that the scientific search for a more complete understanding expressible in progressively more comprehensive theories will continue to be as strikingly justified in the future as it has been in the past—an assumption I believe will prove correct.

It is not possible to set out the evidence here, but there are many signs that the coming period may see the establishment of a *single unified science* covering the inorganic and organic realms and also providing the valid scientific approach to the subject matter of psychology, and possibly also of sociology. The inter-relationships of the different branches of science are already recognized to be of great importance, but are not yet fully understood. In the anticipated unified science the complexity and departmentalism of the different methods of the special sciences might be overcome in a simple and comprehensive synthesis. There is probably no reason why this unified theory should not be as clear and objectively reliable in relation to its wide subject matter, as the classical theories of mathematical physics are in relation to their limited fields. Thus all systematic and objectively confirmed knowledge would be brought within a single and relatively simple order, the apparent complexity of phenomena being recognized as at least partly due to the use of inappropriate methods.

A unified science of this kind must rest on a few fundamental concepts expressed in *universal principles* applicable to all kinds of systems, whether inorganic or organic, material or mental, etc. It is probable that these principles will express a *new conception of natural process as possessing a formative or developmental character*. The conservation principles used by exact science hitherto (for example, the conservation of atoms, matter, energy, momentum, etc.) are proving too limited in scope to account for processes which possess an inherent progressive or one-way tendency (such as the evening out of temperature differences, biological multiplication, growth, differentiation, etc.). It is therefore probable that a unified science must be based on a concept of a formative process, the conservation principles of classical physics applying to those aspects of process where the formative or one-way property is negligible. This means that the new unified science will reveal *the precise scope and limitations of physical measurements*. Quantity would be seen to represent one aspect only of the order of nature, and relations of succession, for example the fact that growth is seldom if ever reversed, recognized as another important aspect of phenomena.

Such a science would throw new light on the relations of wholes to parts, that is of complex systems to their components, so that the behaviour of parts would be understood not only when isolated, but also as components of larger systems. It would then be evident that *the process of the whole often overrides the tendencies of the parts*, so that in many situations the larger system must be considered before predictions can be made about the parts.

But in addition to these general features, the establishment of a simple unified science implies a dramatic situation in relation to the fundamentals of atomic physics. It means that physical research must seem, at least provisionally, to have reached *a limit to the fine structure of matter*, so that neither experiment nor theory will suggest the need for further minute structure within, say, the hydrogen nucleus. Physical theory will have achieved a satisfactory description of all known facts about nuclei, atoms, etc., so that fundamental physics will, at least for the time being, become a *closed subject* offering no fields for further research. The indeterminacy principle, discovered in 1925, has already indicated that there are limits to the possible accuracy of space-time measurement; this may mean that the method of physical analysis,

that is, the division of complex systems into smaller and simpler parts, may have been exhausted. Physics may have touched bottom; research into smaller and smaller regions of space may have come to an end.

In a restricted (and perhaps temporary) sense, physics would have attained absolute knowledge of its fundamentals, and this knowledge would be expressed in a perfected theory. *A wave of theoretical clarification*, based on the universal principles confirmed in physics, would thus pass from fundamental physics through molecular physics to biology, and on towards the mental and social sciences. The unified science would be closed and perfected at one end, and be steadily extended in clarity and scope towards *the science of man.*

This new science of man would imply the coalescence of physiology and psychology in a concept of the human individual overcoming the body-mind dualism.

But this in turn suggests that the new conception of process must be neutral as between matter and mind; it will not suggest that phenomena are either material or mental, but will provide a more general and comprehensive method which can reduce in special cases to the 'purely physical', and in other cases to the 'purely mental' aspects of process. Indeed, the principles of the unified science must stand impartially behind physics, biology and psychology, and show where contemporary physical conceptions are applicable, where biological concepts are valid, and where psychological concepts are necessary. The unified science will not explain biology in terms of physics, or vice versa, but reinterpret the concepts of the sciences of matter, life, and mind in terms of comprehensive principles of which all other principles are special cases. A true scientific synthesis must do no less than this.

So powerful an intellectual instrument will give an unprecedented stimulus to the development of a valid science of man providing a balanced conception of the human person and of society in process of development, and including a recognition of all the requirements of a full human life at different stages of social development. Such a science of man will inevitably in some degree modify man's conception of himself and therefore also his ethical attitudes. A science of man is of necessity more than a science in the classical sense, for it must state the optimal

conditions for individual and social development. The new unified science will therefore itself represent more than science, and might be called a meta-science, or even a metaphysics.

It is hardly possible to exaggerate the influence which the new science would have on thought in all fields, if these speculations were to prove correct. The basic principles of the science would express a universal method of thought, or way of thinking about all natural processes which leads to correct results when properly applied. The proved validity of the method in physics and biology would bring it unique prestige and lead to its immediate application in all realms of thought. Indeed it must be expected that it will affect the entire tradition of thought in all countries where science is honoured. No barrier would for long resist the spread of its influence. No ideology, whether secular or religious, would be capable of surviving into the twenty-first century which could not display its conformity to the basic principles of the new science. On the view presented here, the unified science would ultimately constitute the only universal authority. Beside this new social power, the influence of the world religions and of orthodox marxism would decline, because they are not unassailably rooted in objective universal truth.

The new scientific orthodoxy will not, however, be arbitrary, tyrannical, or static. On account of its objective truth it would be widely acceptable and therefore represent the first power fitted to serve as the instrument of a universal human society in process of development. In recent years an unbalanced and over-technological science has intensified certain harsh, anti-humane, and degrading tendencies in the technical-collectivist society which is developing in many countries. In the long run, only a balanced and therefore humane science can check this tendency and sustain the elasticity and variety which are indispensable to the continued health of any human community.

But we have still to consider the nature of the influence of the new science on thought in general. What will be the main principles of the new method of thought which will enjoy such unique prestige?

First, and most important of all, it is clear that the discovery of universally valid principles will encourage universality in all realms. The new outlook will thus tend to bring together cultures based on contrasted traditions and principles, and so to further

the development of a universal society. The unified science will initiate an epoch of universality.

Moreover, the science will teach that the actual phenomenon is always a process of change; that all attempts to resist or neglect change are ultimately abortive; that all process is of one character, apparent dualism being of limited validity; that the whole in general overrides the parts, and the whole must often be considered before the part; that the role of quantitative factors in determining process is restricted and not always decisive; that process is in general formative and developmental. It will be seen that these principles, though scientific in form, have immediate ethical and social implications when applied to human affairs. Moreover, their influence will in general be towards repairing some of the defects of recent thought. This is not the result of wishful thinking in drawing up this estimate of the future of science. It is inevitable that if man understands nature and himself sufficiently he will find himself knowing how he must think and act if he is to fulfil the potentialities of his own nature. Universal principles alone can guide the thought and action of the individual, just as they alone can promote the development of a universal society.

The principles just outlined are similar to those of dialectical materialism, and like the latter they hold the germ of a world outlook which might contribute to the establishment of a world society. There is little doubt that an event as dramatic and pregnant as the establishment of a unified science might serve mankind well in the coming period. For the sake of that possibility, many lovers of fundamental research may be prepared to accept the loss implied in the attainment of absolute knowledge in certain fields. Certainly from one point of view the perpetual search for knowledge is more inspiring than the prospect of the attainment of final knowledge. The intellect is deadened where there is no more to learn. But the pure search for knowledge is already prejudiced by the urgent demands of the social situation, and the human need for a universal truth which can overcome dualisms and conflicts now overrides all other considerations. In any case, if observation and experiment unquestionably confirm the principles of a unified science, then scientists will have no choice but to accept the situation, even if research in certain fields is thereby brought to an end.

The growth of exact science from 1600 onwards led to a period marked by the hope that scientific research would result in the emancipation of the race, at least from its material needs. This hope marked much of European thought during the late eighteenth and nineteenth centuries. As it proved, science has achieved the possibility of that emancipation from want, but this possibility has not been realized, because the science of the time was unbalanced and undermined religious and traditional attitudes without replacing them by any new conviction of adequate power. Throughout the nineteenth century, many thinkers had given warnings that a mechanical quantitative science, blind to its social consequences, would endanger civilization. Their voices were heard but their message was neglected, until the bitter experiences of the last thirty years made a platitude of their prophecy. One result today is that in the scientific world there now prevails an unhappy sense of disillusionment regarding the ultimate value of fundamental research. Indeed, the assurances that atomic energy will prove of value to industry are too apologetic to issue from anything but a guilty conscience. The tragedy of science today is symbolized in the fact that it became Einstein's role to persuade Washington to take up the research which led to the atomic bomb.

Terrible as these facts are for those who value the enquiring intellect, there is an answer and a way out. On the interpretation presented in this article the contemporary reaction from fundamental experimental research is from one point of view appropriate and even necessary. The greater need today is for theoretical research; for the discovery and formulation of powerful unifying principles; for the restoration of order, simplicity, and significance to knowledge. Experiment and theory are both indispensable to science, and the healthy progress of science depends on a continual oscillation of emphasis from one to the other. The balance should not, and indeed cannot, be held steady. The scientist must go out in search of facts, but he must also sometimes pause to arrange them. There can be no question that the more pressing requirement is now for new theoretical methods appropriate to the vast array of established facts. If, as a consequence of greater attention to theoretical inquiry, a unified science is indeed established, the present disillusionment will pass away, and there will be an extraordinary stimulus to the application of the new absolute

knowledge of fundamentals for the benefit of man. Social disillusion with experimental science will be followed by social confidence in the application of the new theoretical principles.

But what is the immediate value of these speculations? For those who recognize at least the possibility of their proving in some degree correct, who consider that they are of sufficient interest to be taken seriously, I suggest that they contain an important practical implication. If the trend of science is in this direction then theoretical and practical endeavours which are in conformity with this trend are more likely to bear fruit than those which are not. It is therefore worth considering whether all thought and action should not as far as possible be brought into relation to the outlook presented here. If the next half-century is in fact to see the advance to a unified science, a great broadening of human thought, involving the overcoming of many prejudices, must be brought about. Those who work in this direction will at least have the inner satisfaction of taking part in a great historical movement; those who dislike and reject the new ideas, and there are sure to be plenty of these, will provide the resistance and struggle without which no new movement can attain maturity. In the scientific world, as in every other, resistance serves to challenge the new to greater efforts of discipline and achievement.

Every great movement is in essence simple, and this is true of the anticipated unified science and of the social epoch which it will mark. It will be a time of universality, of universal principles displaying a common ground beneath the natural diversity of phenomena and of peoples. It will therefore result in the adjustment of exaggerated or inappropriate contrasts, in philosophy as in the standard of living of the peoples. The period will be one, not of infinite and romantic aspirations, but of the practical task of ordering finite patterns in a finite world. Social change will become less violent and arbitrary, and social action conform more closely to general principles. For it is only through the intellectual discovery of universal principles and their application in practice that the new science and the new society can be established. The purpose of this article has been to suggest that this process is already under way.

LUDOVIC KENNEDY

THE UNCHARTED

THE cruiser *Apollo* was beating north-eastwards across the South Atlantic to Bermuda. Her navigating officer, Lieutenant-Commander Kemp, sat in the privacy of his charthouse, pondering on his chances of promotion. His seniority as Lieutenant-Commander was seven and a half years and his last chance of promotion to Commander would come with the publication of the half-yearly lists on 1 July. It was now the beginning of May.

Kemp was regarded by those who knew him as a conscientious officer of high integrity and character; and it was common knowledge in the *Apollo* that ill luck rather than bad management had so far robbed him of his laurels. As captain of a small vessel during the early days of the war, he had ordered the depth charges to be made ready. The order had been misunderstood with the result that an enemy submarine which ought to have been sunk had got clean away. A Court of Inquiry had remarked tartly that Kemp should have satisfied himself that the order had been carried out; and later Their Lordships had expressed Their views in a letter that showed neither charm nor charity. It had been a small blemish on an otherwise chaste record; but not one (as Kemp himself knew) which an officer seeking promotion could afford.

As he lay stretched on the narrow charthouse bunk, tuning his body to the motion of the ship, listening to the waves slapping monotonously against the sides, he let his mind dwell for a moment on the new horizons that the rank of Commander would open to him. The financial aspect was the most appealing. He would be assured of at least another seven years' employment on a higher scale of pay, and (even if he were not promoted to Captain) an increased pension at the end of them. This thought pleased him less for his own sake than for his wife's. He had married Laura, the beautiful daughter of an impecunious Somerset clergyman, ten years previously. She had borne him four sons, Jonathan, Nicholas, Peter and Paul. Peter and Paul were twins and had been mistakes. They were mistakes he could ill afford. It was not easy to support a large family on Lieutenant-Commander's