MATTER AND ENERGY

BY

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AND RADIOACTIVITY, UNIVERSITY OF GLASGOW

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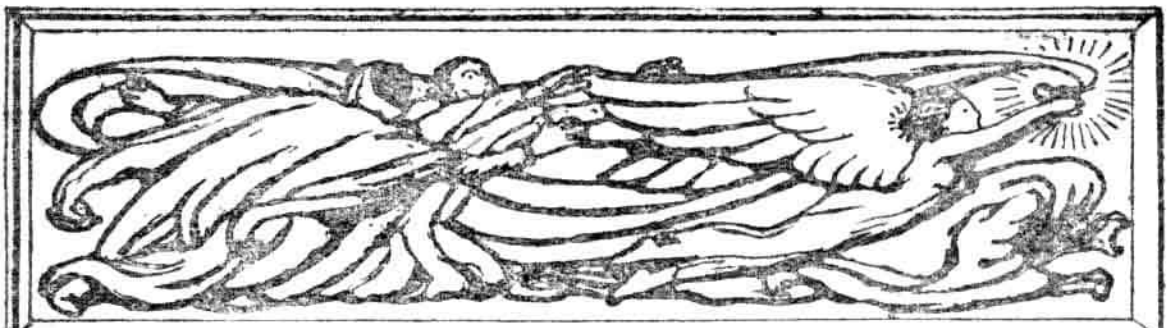

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PERIODIC TABLE

Group O.	Group I.	Group II.	Group III.	Group IV.	Group V.
Helium He 3·99	Lithium Li 6·94	Beryllium Be 9·1	Boron B 11·0	Carbon C 12·00	Nitrogen N 14·01
Neon Ne 20·2	Sodium Na 23·00	Magnesium Mg 24·32	Aluminium Al 27·1	Silicon Si 28·3	Phosphorus P 31·04
Argon A 39·88	Potassium K 39·10	Calcium Ca 40·07	Scandium Sc 44·1	Titanium Ti 48·1	Vanadium V 51·0
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MATTER AND ENERGY

CHAPTER I

PHYSICAL HISTORY

THE behaviour of matter and energy represents one aspect only of human knowledge, which is generally known by the name of physical science. It seems well to state at the outset that, throughout these pages, when the term science is employed it refers solely to this one branch. Physical science enjoys the distinction of being the most fundamental of the experimental sciences, and its laws are obeyed universally, so far as is known, not merely by inanimate things, but also by living organisms, in their minutest parts, as single individuals, and also as whole communities. It results from this that, however complicated a series of phenomena may be and however many other sciences may enter into its complete presentation,

the purely physical aspect, or the application of the known laws of matter and energy, can always be legitimately separated from the other aspects. This aspect comes first, not necessarily in relative importance, but in the order of the scientific definition of the phenomena and of the problems it presents for a solution. A great simplification thereby results, which is too often neglected. Complete ignorance of these laws is, nowadays, rare, for they enter into the general common sense of the age, and any flagrant violation of them is quickly exposed. But the neglect to give precedence to the purely physical aspect of the complicated occurrences and events of human experience in their orderly presentation, has led to much confused history and a general lack of clearness as to the precise terms with Nature on which the race exists on this planet. There is a special branch of study known as physical geography, but the need for a sim lar branch of physical history does not appear to have been widely felt. The laws expressing the relations between energy and matter are, however, not solely of importance in pure science. They necessarily come first in order, in the fundamental sense described, in the whole record of human experience, and they control,

in the last resort, the rise or fall of political systems, the freedom or bondage of nations, the movements of commerce and industry, the origin of wealth and poverty, and the general physical welfare of the race. If this has been too imperfectly recognised in the past, there is no excuse, now that these physical laws have become incorporated into everyday habits of thought, for neglecting to consider them first in questions relating to the future. It is an interesting and by no means hackneyed side of the subject to consider, so far as the operation of purely physical laws can teach, exactly what the future has in store for this world and the complicated civilisation that it contains. Is it a stable and permanent movement, or does it carry in itself, like the life of the individuals that comprise it, the seeds of its own inevitable decay ? Moreover, if, as will transpire when the nature of the controlling physical laws has been made clear, it is ephemeral and will decline the sooner the more rapid its development and the more glorious the zenith it attains, what alteration of the existing conditions would suffice to convert it into a physically stable and permanent movement ? On these great questions, rendered the more fascinating because of the disposition, since

the development of the doctrine of evolution, to consider the fate and future of the individual as of little importance compared with the fate and future of the species, physical science in its later developments has much to say that is of general interest. The proverb counselling the cobbler to stick to his last is a good one; but since the province of physical science is the universe and all that moves therein, its right to be heard first, in order of presentation of the subject only, cannot be withstood. It may or may not assist in disclosing the fundamental bearings of any question, but anything it has to say will in general be definite and, in so far as the laws are perfectly known, incapable of being invalidated by any other considerations whatever. The laws may not be fully known and may give rise to false deductions, a case of which arose in the question of the duration of geological time. In such a case, the discussion of the conflicting evidence can only result in the advance of knowledge. Physical science, by reason of the universality of its laws, has something to say on almost every subject. It need only be stated once for all, that although the purely physical side can be considered separately, it does not render other points of view less necessary, though, of

course, it is only with the physical point of view that the present volume is concerned. To adopt for the moment the language of Spencer's *Classification of the Sciences*, referred to in the Introductory volume of this Series (p. 89), physical science supplies subject-matter for every actual occurrence in the universe, but none of the truths outside of physical science can help in the solution of physical problems.

The recognition of the fundamental physical conditions which control the destinies of a race, too often occurs too late in its development to be of service. History throws some strange sidelights on this blindness to the obvious. The upward progress of the race has, for example, been classified into succeeding eras, each designated by the name of a material. Thus are distinguished the Stone Age, the Bronze Age, the Iron Age, and the Steel Age. The names indicate that the era in question was associated with a certain degree of mastery over a particular material sufficient to enable new weapons to be forged in the struggle for existence. Yet, when the early records of these eras are examined, little or nothing is found about the pioneers whose knowledge and craft effected these broad advances Often were they held in

such contempt that it was considered almost beneath the dignity of an educated man even to make himself superficially acquainted with the technical processes to which, in the judgment of history, his era owed its initiation. To come to more recent times, how many people blessed with a liberal education would be at a loss if asked offhand what steel is, and how it is distinguished from iron; or would recognise even the names of the great founders of the modern era?

Fundamental as materials are in shaping the broad lines of progress, it is necessary to go but very little deeper to come upon something equally fundamental but less obviously so. Materials are employed merely as weapons, tools, or instruments for the utilisation of power or energy. Even the food we eat is not the end but the means of living. Life is physically distinguished from death by movement, and what food is to the motion of living organisms, fuel is to the motion of mechanical engines. With the advent of steel the utilisation of the natural sources of energy has progressed with enormous strides. Less than a hundred years ago little was known about energy, and, indeed, the modern idea of energy as a definite fundamental existence was not

developed till well on in the last century. Isolated examples of energy, apart from that of living beings, have been known necessarily and some have been utilised from the remotest times. The wind that propels the sailing ship was probably one of the first forms to be harnessed to the affairs of life. The phenomena of fire, and the thermal energy derived from it, were known to all but the most primitive races, though its recognition as one of the manifestations of energy is not yet a century old. Not until the law of the conservation of energy was established, and it was shown that energy like matter is indestructible and uncreatable, could energy be regarded as one of the fundamental physical existences. Its recognition, as a separate entity, distinguishes the present age from all its predecessors. This is the Age of Energy, or rather this is the beginning of the ages of energy, the Age of the Energy of Coal. The triumphs of this age have been sung in season and out of season. Already, however, science has outgrown such immature jubilation. That this still is the age of the energy of coal is unfortunately only too true, and the whole earth is rendered the filthier thereby. Moreover, the age will last just so long as the

coal supply lasts, and after that the last state of the race will be worse than the first, unless it has learned better. Only ten years ago the prospect was, in fact, anything but a cause for jubilation; but these last years have wrought a wonderful revolution in our knowledge of energy, and therefore in the future outlook of the race, now entirely bound up with that of energy. It is possible to look forward to a time, which may await the world, when this grimy age of fuel will seem as truly a beginning of the mastery of energy as the rude stone age of paleolithic man now appears as the beginning of the mastery of matter. It may await the world, but by no means of necessity awaits it. The prospect is physically possible, but the realisation depends also upon man and whether he can ever hope to rise to the heights of knowledge the problem demands. The discoveries in connection with the recently explored field of radioactivity have put an entirely different complexion on the question as to how long the energy resources of the world may be expected to last. It has transpired that there exists in matter, associated with its ultimate atoms, that is, by definition, with the smallest particles capable of separate existence of the elements