

The experiments only *appear* to indicate a change of wave-length produced by scattering. It is possible that, of these cases, the J transformation occurs at the birth in the scattered radiation. But facts of much greater significance are these :

As the frequency of the X-radiation increases we can, in many cases, observe the quite abrupt transition from an unmodified scattered radiation to the modified scattered radiation. There is a gulf between the two which makes the identification unmistakable and shows that some special condition is essential to the production of the modified scattered radiation. We can, in selected cases, take the unmodified scattered radiation and transform it into the modified scattered radiation, even identifying the thin sheet of absorbing material which affects the transformation—quite outside the scattering substance.

These are not isolated results, nor are they of the hazy, indefinite kind which some seem to suspect. The changes are of a magnitude several times the magnitude of the possible error. The phenomenon has all the characteristics of the J-phenomenon as observed originally in primary radiations, and as briefly indicated above.

It is not intended here to discuss either the process or even the nature of the transformation involved, for though many experiments have been made, many more are necessary before we can get a secure foundation for any theory. The phenomenon is not scattering nor is it fluorescence with the emission of characteristic radiation as generally understood; it is a new—a third X-ray phenomenon. Without committing oneself to an opinion, it may be stated that there is the appearance of a sudden absorption of the beam followed by a re-emission of radiation of somewhat greater wave-length proceeding in the original direction of propagation. Absorption laws break down; methods of comparing intensities of radiation are no longer applicable. This needs to be borne in mind in experiments upon penetrating radiations. It seems highly probable, for example, that in experiments on the absorption of penetrating X-rays and γ -rays, the transmitted beams produce far too much ionisation for their energy, and thus appear not to be absorbed so strongly as they really are. For we have observed sudden

increases of ionisation of so much as 100 per cent. due to a very slight diminution in wave-length. Thus there seems little doubt that when penetrating X- and γ -rays are transmitted through thick layers of absorbing material, the ionisation coefficient is suddenly increased at certain points (under certain conditions the change may be gradual), and the transmitted radiation then produces a greater effect than is accounted for by intensity alone. It appears more penetrating than it really is.

CONCLUSIONS.

The broad conclusions are that under certain conditions not yet identified, but apparently depending on the rate of energy absorption, discontinuities occur in the absorption of X-radiation accompanied by corpuscular emission from the absorbing substance and ionisation when that substance is in the gaseous state. The transmitted primary radiation behaves as a transformed radiation.

No direct evidence of the emission by the absorbing substance of a characteristic X-radiation (of J series) has been obtained. If it exists it must be very feeble. What originally appeared to be a fluorescent radiation (and to others a modified scattered radiation) has been found in some cases to be merely the scattered radiation transformed by transmission through matter after its production. The radiation when observed is neither characteristic nor scattered, but is the scattered radiation after having been transformed by the J process (a process similar in many ways to fluorescence with the emission of characteristic X-rays). The necessity for critical conditions suggests obedience to the quantum laws in some form. The well-known laws of X-ray absorption break down when the critical conditions are reached.

Though it is realised that some of the results here recorded will possibly need re-statement or modification when they are tested by experiments extending over a wider range of conditions, the results already obtained are so absolutely new, so remarkable, that they seem to justify publication before a solution of the whole problem has been found. Further investigation of the subject promises to lead to some of the most interesting and important generalisations.

Historical Tradition and Oriental Research.¹

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IT has often been remarked that the outstanding trait of the untrained mind is credulity. The rationalisation of man's views of the world has been a very slow process and it is still very far from a completed process. It has commonly been thought to have begun with the Greeks, but its origin must be sought in the Orient in a period long before Greek civilisation had arisen. The Edwin Smith Medical Papyrus, acquired in 1906 by the New York Historical Society, discloses the inductive process of scientific investigation already in operation in the seventeenth century before Christ. For example, this document contains the earliest occurrence of the word "brain" anywhere appearing in surviving records of the past. The word is unknown in Old Testament

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Hebrew, in Babylonian, Assyrian, or any of the ancient languages of Western Asia. The organ itself therefore was evidently discovered, and the recognition of its various functions was begun, for the first time by these physicians of early Egypt in the thousand years preceding the seventeenth century B.C. The observations recorded in the Edwin Smith Medical Papyrus show that its author had already observed that control of the members and limbs of the body was localised in different sides of the brain; and the recognition of localisation of functions in the brain, mostly the work of modern surgeons and others within the past generation or two, had already begun in the seventeenth century B.C., at a time when all Europe still lay in savagery or barbarism.

There is in existence part of an original transit

instrument, made, as stated by the inscription upon it, by no less a king than Tutenkhamon, in the fourteenth century B.C. It did not come from the tomb of Tutenkhamon, but was apparently made by him for the tomb of his (or his wife's) great-grandfather, Thutmose IV. (fifteenth century B.C.). This and another such piece at Berlin are the oldest scientific instruments of any kind now known to us. It was used for determining meridian time, especially at night, in order that the observer might then set his water-clock, with its 24-hour divisions, a division of the day which thence passed over into Europe in Hellenistic times, whence it was transmitted to us.

Now Herodotus reports a tradition current in his day (fifth century B.C.), that the Greeks were greatly indebted to Egyptian knowledge. This tradition has in recent times been universally rejected; but it would seem that there was much truth in the tradition transmitted to us by Herodotus, and that its complete rejection by classical prejudice is unjustifiable.

The fact that the early Egyptian scientific worker employed an inductive method so far back as the seventeenth century B.C. does not, however, mean that he had completely banished from his mind all belief in magic or in supernatural forces. This truth has been well demonstrated for later ages by Prof. Lynn Thorndyke in his monumental volumes on "The History of Magic and Experimental Science." Undoubtedly the Greek took the longest step in freeing his mind from inherited religious and traditional prepossessions. Using astronomical observations undoubtedly drawn from Babylonia, Thales predicted a solar eclipse in 585 B.C. Astonishing as it seemed to the Greeks, there is little probability that this feat was an unprecedented achievement. What *was* unprecedented, however, was the revolutionary generalisation which Thales based upon his ability to make such a prediction. For he banished the erratic whims of the gods from the skies and discerned the sway of natural law throughout the celestial world. To tear away and fearlessly to trample under foot beliefs and superstitions which had been sanctified by age-long religious veneration demanded dauntless loyalty to his own intelligence. This first supreme enthronement of the human mind was probably the greatest achievement in the career of man.

We can pay no greater tribute to such Greek thinkers than to recognise, that although they put credulity to rout, they could not banish it altogether. It has survived with extraordinary persistence even to the present day. In modern times it was of course the tremendous significance of the discoveries of Galileo which most impressively reproclaimed the supremacy of natural law and the sovereignty of the human mind in discerning that law.

From Galileo's struggle with the church to Huxley's debate with Gladstone, the heavy guns of natural science have dealt tradition one destructive blow after another. It has been under this destructive attack at the hands of natural science that historical criticism has grown up in modern times since Niebuhr. Indeed it has been no accident that in the United States the first serious discussion of the Old Testament narratives in Genesis and Exodus was written by Thomas Cooper, who was the associate of Priestley in the discovery of

oxygen. Cooper was Thomas Jefferson's appointee as first president of the new University of Virginia; but in the Virginia of that period the social feeling against Cooper for having assailed the literalistic interpretation of the Old Testament was so strong that Jefferson was unable to secure his induction into office. Jefferson's influence, however, secured Cooper's appointment as president of the University of South Carolina, where public opinion was at first not so strong against him as in Virginia. It is interesting to note that before the end of the 'twenties, that is, less than a century ago, conservative sentiment was strong enough to bring about Cooper's dismissal from the University, although his personal popularity was such that he was promptly appointed to codify the laws of the State, and the first legal code of the State of South Carolina was edited by this gifted representative of natural science and historical criticism.

The merciless critical scalpel which had not spared Hebrew tradition was equally unsparing in its treatment of the cherished classical heritage from Greece and Rome. The tales of Romulus and Remus, the Trojan war, and the entire cycle of legends which were linked with it, were shorn away. A critical attitude of universal negation arose. It included the whole Mediterranean and Oriental world: Rome, Greece, Hebrews, Babylonians, Assyrians, and Egyptians. Historical criticism would not allow that early man at the beginning of the age of writing had ever heard and transmitted an echo from earlier ages, which, because they possessed no writing, could only send on their story in the form of oral traditions. This attitude of the historical critic may be compared with that of an observer who stands on a mountain peak, and, looking off across a distant landscape to a dim horizon shrouded in mists and cloud, insists that the intermittent glimpses of mountain profiles which vaguely emerge on the far-away skyline cannot correspond to any reality. In short, without ever having been himself on the ground to investigate, he denies the existence of the phantom mountains on the horizon.

The orientalist, if he be something more than a philologist, may be compared with the explorer who pushes out to that distant horizon, and is able to determine on the ground whether the phantom mountains really exist. Such investigation is, however, relatively recent, and the historical critic could scarcely anticipate that it was coming. He seemed to be quite safe in sweeping away all early human tradition. It dealt with a world of gods, demi-gods, and heroes; it was dominated by the whims and caprices of angry or jealous divinities, and it was filled with impossible wonders and prodigies. How could a soundly critical historian accept narratives which seemed so manifestly impossible? We must grant that in the circumstances rejection complete and unqualified seemed the only safe course.

Such critical negation was supreme when, fifty years ago, archaeology began to reveal with startling vividness the facts and the daily equipment of human life in the very ages with which the rejected traditions dealt. In the seventies of last century the excavations of an untrained observer from the outside disclosed an astonishing vision of pre-Greek civilisation at Tiryns, Mycenæ, and Troy. The incredulity with which these

discoveries of Heinrich Schliemann were greeted by the classicists was highly characteristic. His excavations recovered and exhibited to the incredulous eyes of the destructive critics the whole material equipment of daily life from the very age of the Trojan war (or wars), and from the very city in and around which it was waged.

Similar revelations, involving far earlier periods of time, rapidly disclosed the successive stages of the human career from a remote antiquity, reaching well back of the beginnings of the world as dated by an alleged "Biblical" chronology. In dealing with the traditions of these earlier ages the orientalist soon developed a similar school of negative criticism. Such traditional accounts were promptly thrown into the discard. Maspero's bulky history of the oriental peoples, still a standard work on most modern library shelves, tells us that Menes, the first king of the First Dynasty of Egypt, was a purely mythical or legendary figure. Nevertheless we now possess his tomb, and in our collections at the University of Chicago we have a piece of his personal ornaments, a gold bar bearing his name in hieroglyphic—the oldest piece of inscribed jewelry in existence. Since 1894, thousands of prehistoric graves have been excavated along the margin of the Nile Valley, revealing to us the successive stages of human advance for many centuries before the once legendary Menes.

Much the same process is going on in the investigation of Babylonian history. Even the mythical hero Gilgamesh, the original of the European Hercules, bids fair to emerge at last as a remote city king of early Babylonia, who gained a reputation for his prowess in war, until he became the typical and proverbial strong man of all ages.

The crowning disclosure in this unprecedented series of unexpected revelations has recently come from Asia Minor. Nearly twenty years ago the German Assyriologist, Hugo Winckler, visited the mounds of Boghaz (or Boghaz Köi—"Boghaz village") in central Asia Minor. As he walked over the ruins he kicked up with his boot heel several cuneiform tablets, lying practically on the surface. Below were piled the clay tablet archives of the Hittite "Foreign Office," the earliest of which had been lying there at the capital of the Hittite Empire since the middle of the second thousand years before Christ. The result has been the decipherment of ancient Hittite, or rather a whole group of Hittite, dialects. The War has intervened, and since Winckler's death the progress of examining this enormous body of archives has unavoidably been very slow. We owe a great debt, especially to Hrozný and Forrer, for the invaluable disclosures which they have wrung from these documents.

One of these tablets reports a war of Atreus, king of Achaia, against the king of Caria at about the middle of the thirteenth century, that is, about 1250 B.C. There can be no doubt that in this tablet we have a contemporary reference to the cycle of Trojan wars—a reference which must be regarded as an irreproachable historical source, as old as the events which it records. Thus out of the lost oriental background of Greek history in Asia Minor comes a *written* document confirming a Greek tradition, born in an age when the

Greeks themselves still lacked writing. Because writing reaches further back in the Orient by nearly three thousand years than it does in Greece, we are able to confirm Greek tradition out of contemporary written sources.

It has long been recognised that in the early development of Greek civilisation the cities of Asia Minor took the lead. Thales, who lived in one of these cities, was an example of this early stage of Greek culture in Asia Minor. It is also evident that the inland background of oriental culture contributed much to this early development of Greek civilisation on the western fringes of Asia. It is out of this newly recovered oriental background that we are slowly regaining the earlier forerunners of Greek civilisation.

This contemporary reference to the Trojan war is an epoch-making revelation, which must react powerfully upon our treatment of early human traditions. It at once demonstrates that such traditions must not be thrown to the scrap-heap, but rather carefully divested of gods and goddesses, prodigies and wonders, and then examined for the nucleus of sober fact upon which the legendary tale has been built up.

As we look back upon our earliest historical horizon, we now know that the men who stood there in the grey dawn of the age of writing were able to hear echoes of a remoter past, transmitted in the form of oral tradition, of which some portion was then committed to writing and thus survived. In our modern effort to recover and reconstruct the story of man's past career, we have thus rehabilitated a new body of sources, however cautious it behoves us to be in making use of them. Not credulity alone, but also historical method, demands that we recognise these traditions, or the nucleus of fact to be drawn from them, as a body of sources to be restored to their proper chronological position in the succession of surviving evidences which reveal to us the past career of man on earth.

We are the first generation of men able to survey that career without a serious break. As we marshal the evidence for its successive stages, the humanists stand shoulder to shoulder with the workers in natural science, for as we look backward it is the materials and the methods of the geologist which confront us first. The geologist is succeeded by the palæontologist, the anthropologist, the anthropogeographer, and the archæologist. It is at this point, on the border land between the investigations of the worker in natural science and those of the humanist, that we must insert these long-discarded echoes from an age able to transmit only oral tradition, the true value of which oriental research has now interpreted to us. The Homeric songs of the Trojan war can no longer be regarded as exclusively noble literature, of purely legendary content; and, in the presence of these earliest surviving monuments of science, the Greek tradition of substantial Egyptian contributions to knowledge must not be rejected as baseless. There is every possibility that the tombs of Egypt may yield us further scientific treatises like this great Edwin Smith Medical Papyrus, and we cherish the hope that the thirty-five or forty chests, boxes, and caskets still lying in the innermost chamber of the tomb of Tutankhamon with their seals unbroken may contain written documents.