Conversion in Science.¹

By Prof. G. ELLIOT SMITH, F.R.S.

ON Nov. 13, 1859, eleven days before the publication of "The Origin of Species," Darwin wrote: "If I can convert Huxley, I shall be content."

Before his work was published Darwin fully realised the difficulties of the task he was undertaking in trying to convince his fellows of the reality of evolution. Hence he was anxious to secure the help of Hooker, Lyell, and Huxley. When we recall the obstacles that throughout the ages have ever hindered the advancement of learning, and in particular the efforts of isolated pioneers to obtain recognition for views that ran counter to strongly entrenched traditions, we can appreciate Darwin's good fortune in securing the sympathetic consideration of three such exceptional men as Sir Joseph Hooker, Sir Charles Lyell, and Thomas Henry Huxley. Different as they were in temperament and mental attitude, each of them in his own department was endowed, not only with wide and exact knowledge, but also with rare powers of clear insight and sound judgment. If he could convert Lyell, Hooker, and Huxley, Darwin knew that the future could take care of itself.

There never was any doubt about Hooker's attitude: for he had been so intimately associated with Darwin in the building up of the argument that they may be said to have kept step in the advance. But Lyell and Huxley had yet to be won over. If Lyell did not give his active support to the great scheme until the battle was won—largely as the result of Huxley's persistent championship—it must not be forgotten that his book, "The Principles of Geology," was, as Huxley expressed it, "the chief agent in smoothing the road for Darwin."

"It brings home to any reader of ordinary intelligence a great principle and a great fact—the principle that the past must be explained by the present, unless good cause can be shown to the contrary; and the fact that so far as our knowledge of the past history of life on our globe goes, no such cause can be shown."

Huxley finished reading the proof of the "Origin" two days before the book was published, and on the following day Darwin received his verdict in these words: "I think you have demonstrated a true cause for the production of species, and have thrown the *onus probandi*, that species did not arise in the way you suppose, on your adversaries."

It is difficult for us at the present time to appreciate Huxley's reluctance to accept the fact of evolution. For once the morphological similarities of nearly related animals were appreciated, and the essential identities in ontogeny were admitted, what explanation was possible other than the recognition of a common origin? The idea of evolution was of course familiar to him, and had been the subject of repeated discussions with Herbert Spencer and others.

In his essay on "The Reception of 'The Origin

of Species' " Huxley has given a characteristically frank account of his own conversion. While he "had long done with the Pentateuchal cosmogony," even the persistence and the dialectic skill of Herbert Spencer were impotent to persuade him to admit the reality of evolution. He justifies his stubborn refusal, not because the unconvincing arguments of Lamarck and the author of "Vestiges of Creation" antagonised him, for, as Dr. Chalmers Mitchell clearly showed in his Huxley Memorial Lecture a year ago, Huxley had a peculiarly keen sense of logic and cogency, but because "the evidence in favour of transmutation was wholly insufficient, and no suggestion respecting its causes had been made which was in any way adequate to explain the phenomena." He did not accept the hypothesis of natural selection as the adequate explanation: but Darwin's insistence on the facts revealed by selective breeding of domestic animals and plants convinced Huxley of the possibility of finding natural factors to establish the fact of transmutation. No longer did he harbour any doubt as to the reality of evolution. To quote his own words:

"I imagine that most of those of my contemporaries who thought seriously about the matter were very much in my own state of mind—inclined to say to both Mosaists and Evolutionists, 'A plague on both your houses!' and disposed to turn aside from an interminable and apparently fruitless discussion, to labour in the fertile fields of ascertainable fact. And I may therefore suppose that the publication of the Darwin and Wallace paper in 1858, and still more that of the 'Origin' in 1859, had the effect upon them of the flash of light which, to a man who has lost himself on a dark night, suddenly reveals a road which, whether it takes him straight home or not, certainly goes his way. That which we were looking for, and could not find, was a hypothesis respecting the origin of known organic forms which assumed the operation of no causes but such as could be proved to be actually at work. We wanted not to pin our faith to that or any other speculation, but to get hold of clear and definite conceptions which could be brought face to face with facts and have their validity tested. The 'Origin' provided us with the working hypothesis we sought. Moreover, it did the immense service of freeing us for ever from the dilemma—Refuse to accept the creation hypothesis, and what have you to propose that can be accepted by any cautious reasoner? In 1857 I had no answer ready, and I do not think that anyone else had. A year later we reproached ourselves with dullness for being perplexed with such an inquiry. My reflection, when I first made myself master of the central idea of the 'Origin,' was 'How extremely stupid not to have thought of that!' I suppose that Columbus' companions said much the same when he made the egg stand on end. The facts of variability, of the struggle for existence, of adaptation to conditions, were notorious enough; but none of us had suspected that the road to the heart of the species problem lay through them, until Darwin and Wallace dispelled the darkness, and the beaconfire of the 'Origin' guided the benighted."

This illuminating confession is the clearest and

¹ From the Huxley Memorial Lecture, delivered at the Royal College of Science, South Kensington, on May 4.

most searching analysis we have of the factors that play a part in the process of conversion in science. Huxley was a man of rare insight and courage: he had at his command all the information that was necessary to convince him, not only of the reality of evolution, but also of the fact that man could not be left out of the scope of the process of transmutation once he accepted it. Yet he held back. He needed a working hypothesis to convince him of the possibility that transmutation might be effected by some natural process.

Huxley's great service to learning was not simply the fact that once he was convinced of the truth of evolution he devoted himself to the task of converting the world of educated men and women, but that he concentrated attention upon the problem of man's status. By so doing he effected perhaps the greatest revolution that has ever been effected in the attitude of mankind to knowledge in general, for all learning is inevitably centred upon man and his relationship to the Universe.

It is the human aspect of the problem that I specially want to study in this lecture.

It is one thing to convert men of exceptional insight and understanding such as Hooker, Huxley, and Lyell, but quite a different matter to convince men of average ability. Darwin complained that he "found the most extraordinary difficulty in making even able men understand at what he was driving" (letter to W. B. Carpenter, 1859). In particular was he distressed by the unfair and ignorant criticisms of opponents who failed to understand his theory. In December 1860 he was forced to admit: "I can pretty plainly see that if my view is ever to be generally accepted, it will be by young men growing up and replacing the old workers, and then young ones finding that they can group the facts and search out the new lines of investigation better on the notion of descent than on that of creation." This is true of all learning that is coming for the first time under the influence of the scientific discipline. Its hope is in youth and the coming generation rather than in men already involved in the shackles of conventional views, who, as Anatole France expressed it, "are no longer curious."

This is a true picture of what usually happens in any progressive movement. The number of men competent to understand a new generalisation and apply it in practice is lamentably small. As Darwin confessed, we have to look at young men, who are free from traditional obsessions and are ready to embark on new adventures that seem hazardous to their elders. Before their views become set in a rigid mould men would welcome hypotheses that provide satisfying explanations of the growing knowledge and provocative ideas to stimulate new inquiries.

The two great obstacles that stand in the way of the acceptance of a new interpretation of evidence are exemplified in the cases of Lyell and Huxley. The former was hampered by tradition, the force of which it took eight years to overcome. Huxley was no longer under the influence of such restraints against clear thinking. His only reason for

hesitancy was the fact that he could not imagine how evolution could be effected by known natural agencies. Hence when Darwin put forward a hypothesis to supply what was lacking, Huxley's conversion was, as he himself has explained, instantaneous.

Huxley has discussed with characteristic clearness and decision the much-misunderstood function of working hypotheses in science. I make no excuse for quoting him once more on a subject so directly relevant to my present argument.

In the preface to the English edition of Haeckel's book on "Freedom in Science and Teaching" (1879) he wrote:

"No profound acquaintance with the history of science is needed to produce the conviction that the advancement of natural knowledge has been effected by the successive or concurrent efforts of men whose minds are characterised by tendencies so opposite that they are forced into conflict with one another. The one intellect is imaginative and synthetic; its chief aim is to arrive at a broad and coherent conception of the relations of phenomena; the other is positive, critical, analytic, and sets the highest value upon the exact determination and statement of the phenomena themselves.

"Every science has been largely indebted to bold, nay, even to wild, hypotheses, for the power of ordering and grasping the endless details of natural fact which they confer; for the moral stimulus which arises out of the desire to confirm or to confute them; and last, but not least, for the suggestion of paths of fruitful inquiry, which, without them, would never have been followed. From the days of Columbus and Kepler to those of Oken, Lamarck, and Boucher de Perthes, Saul, who, seeking his father's asses, found a kingdom, is the prototype of many a renowned discoverer who has lighted upon verities while following illusions which, had they deluded lesser men, might possibly have been considered more or less asinine.

"Nor have I, for one, anything but cordial assent to give to his declaration, that the modern development of science is essentially due to the constant encroachment of experiment and observation on the domain of hypothetical dogma; and that the most difficult, as well as the most important, object of every honest worker is 'sich entsubjectiviren' to get rid of his preconceived notions, and to keep his hypotheses well in hand, as the good servants and bad masters that they are."

Assuming the rôle of champion of evolution, Huxley boldly attacked the most contentious issue and made "Man's Place in Nature" the cardinal issue of the conflict. The particular field that Lyell avoided, Huxley selected as his chosen battleground. In putting man into the centre of the picture Huxley was doing again, though in a vastly different way, what the French humanitarians did in the eighteenth century. Rousseau wrote in 1754: "The most useful and least advanced of all human knowledge seems to me to be that of man himself." However paradoxical this statement may seem, there can be no question of its truth. The question of man's origin and history, and the interpretation of human nature and behaviour, are problems that vitally affect and interest every human being. The essential subject matter of ethnology necessarily comes within the knowledge

of every human being. Each individual is aware of his own thoughts and actions, and is vitally interested in the behaviour of his fellow men and women. Everyone therefore knows from his own experience the essential truth concerning the great problems concerning which scholars have been wrangling for two centuries. Why then, it will be asked, is there any difference of opinion when everybody knows the truth? The answer to this query is provided by the history of the last two centuries, for to-day the truth is still obscured by the survival of the old conflict between the followers of Descartes and those who adopted the discipline of Newton.

In the remote past, all inquiries, whether astronomical or chemical, botanical or zoological, mathematical or physical, were essentially anthropocentric. In most early speculations what man was striving after was not knowledge, but the means of safeguarding his own life and prosperity. After the demolition of astrology, when this crude type of anthropocentrism was superseded, the attainment of the strict discipline of the scientific method was determined by the extent by which men could eliminate human emotions from their inquiries.

Huxley's achievement differed profoundly from the early revolutions in thought. While the latter aimed at subordinating the forces of Nature for man's benefit, Huxley's object was to assign man to his true place in Nature, and to discover his origin as a part of the natural processes. But his interest was not restricted to the biological aspects of the problem. He boldly plunged into the discussion of the cultural aspects of anthropology and, although he quoted the familiar phrase that had been handed down from the Cartesian scholastics of the eighteenth century, he refused to accept the theory of "the similarity of the working of the human mind" as an adequate explanation of anything more than the simplest of inventions. Writing in the same year (1865) Mr. (afterwards Sir Edward) Tylor spoke with equal emphasis in favour of diffusion as the only possible interpretation of the facts; but in 1871 a subtle change was taking place in his opinions. Then he was admitting in the preface of his "Primitive Culture" the fact of his indebtedness to Adolf Bastian. While criticising in the most scathing terms, and with a wealth of forcible illustrations, his contempt for those who had pretended to ignore the historical method and the principles of diffusion of culture, Tylor himself was drifting towards the very views he was denouncing. He was developing his theory of animism (that there was an innate tendency in mankind to attribute life and soul to inanimate objects around them), and this enunciation of a 'natural law' brought about a sudden lapse into the Cartesian error, from which ethnology is still suffering.

It is a thousand pities that, when Tylor thus abandoned the Newtonian discipline, Huxley did not continue to insist upon the true principle of ethnology which he defined so clearly in 1865. But he was too fully occupied with biology to have time for ethnology, which he left to Tylor.

I have already referred to the important part

played by Lyell's principle of continuity in geology in preparing the way for the acceptance of biological evolution. Yet a century before Lyell's time, essentially the same principle of continuity had been confidently applied to human affairs by Turgot, in words described by the late Lord Morley,² as "among the most pregnant, as they were among the most original, in the history of literature, and reveal in an outline, standing clear against the light, a thought which revolutionised old methods of viewing and describing the course of human affairs, and contained the germs of a new and most fruitful philosophy of society." The tragedy is that the true philosophy of society enunciated by Turgot in 1750 did not revolutionise old methods of viewing and describing the course of human affairs. In spite of Lord Morley's appreciation, as just as it is eloquent, of the greatness of Turgot's achievement, men failed to apply his teaching for the salvation of humanistic studies. It is, in fact, the most urgent need of ethnology at the present time that this long-delayed reform should begin. Turgot contrasted the operation of the laws of Nature with the behaviour of mankind.

"The phenomena of nature, subjected as they are to constant laws, are enclosed in a circle of revolutions that remain the same for ever! . . . The succession of men, on the contrary, offers from age to age a spectacle of continual variations. Reason, freedom, the passions, are incessantly producing new events. *All epochs are fastened together by a sequence of causes and effects, linking the condition of the world to all the conditions that have gone before it.* The gradually multiplied signs of speech and writing, giving men an instrument for making sure of the continued possession of their ideas, as well as of imparting them to others, have formed out of the knowledge of each individual a common treasure, which generation transmits to generation, as an inheritance constantly augmented by the discoveries of each age; and the human race, observed from its first beginning, seems in the eyes of the philosopher to be one vast whole, which, like each individual in it, has its infancy and its growth." (Lord Morley's Translation.)

This is a clear and definite statement of the principles of diffusion of culture, for the recognition of which some of us are still fighting to-day, more than one hundred and seventy years after Turgot.

Two centuries ago Fontenelle, the enthusiastic disciple of Descartes, was expounding the facts of human society in terms of his master's idea of "natural laws," and was pouring scorn on the historical method and the principle of continuity. In Scotland, where Cartesian philosophy retained a hold long after it had been replaced by the Newtonian discipline in England, and even in France, the ethnological teaching of Fontenelle survived the criticism of Turgot, and in 1777 was given a concrete form by Dr. William Robertson, Principal of the University of Edinburgh, in his "History of America." He maintained that the ancient civilisation of America was of independent origin; and in support of his speculation he referred to "such a resemblance in their manners and customs as necessarily arises from a similarity

² Lord Morley, in his article on Turgot in "Biographical Studies."

of their condition," a form of phraseology which, after nearly a century of half-hearted lip service, suddenly acquired the force of a dogma, when, having been revived by Adolf Bastian in 1860, it was adopted in 1871 by Sir Edward Tylor. Thus modern ethnology was brought under the influence of Cartesian philosophy.

Since Newton rescued astronomy and physics from the stranglehold of Descartes' method, every branch of science in its turn has been emancipated. Ethnology alone remains in the bonds of such superstition. For more than a century, it is true, men continued to render lip service to Turgot's recognition of the fundamental factors underlying human institutions, without, however, applying them with full understanding and consistency. Under the influence of Lyell's revival of the idea in reference to geology, Tylor in 1871 reaffirmed the fundamental importance of the principle of continuity and the historical method as the essential factors in the interpretation of the facts of ethnology. Thus in the first edition of "Primitive Culture" he wrote:

"The notion of the continuity of civilization is no barren philosophic principle, but is at once made practical by the consideration that they who wish to understand their own lives ought to know the stages through which their opinions and habits have become what they are (p. 17). History, taken as our guide in explaining the different stages of civilization, offers a theory based on actual experience. This is a development-theory, in which both advance and relapse have their acknowledged places. But so far as history is to be our criterion, progression is primary and degradation secondary; culture must be gained before it can be lost. Moreover, in striking a balance between the effects of forward and backward movement in civilization, it must be borne in mind how powerfully the diffusion of culture acts in preserving the results of progress from the attacks of degeneration. A progressive movement in culture spreads, and becomes independent of the fate of its originators" (p. 34).

Just as Huxley and Darwin in 1860 had to expose the fallacy that evolution did not necessarily imply

progress, so Tylor had to explain, as Turgot had already done in 1750, that there is in man no innate impulse to compel him to embark on what we call progress. Yet this very error is the fallacy underlying present-day speculation. By a strange irony this reaffirmation of the sound principles that should find expression in all humanistic inquiries occurs in a book that was reviving the appeal to 'constant laws,' against which Turgot protested. For by claiming that mankind as a whole display an innate tendency to develop animistic beliefs Tylor was inventing a 'law of Nature' for which there is no evidence. While referring to this flagrant defiance of the principle of continuity, one is tempted to quote Tylor's own warning. For the learned author of "Primitive Culture" himself discusses (vol. 1, pp. 378 and 379) with characteristic frankness the curious phenomenon that ethnologists enunciating certain views often cite evidence stultifying their own opinions. After giving specific illustrations of this neglect of logical consistency he makes this interesting comment: "Such cases show how deceptive are judgments to which breadth and generality are given by the use of wide words in narrow senses."

The late Sir Edward Tylor thus missed the great opportunity of giving full expression to the principles enunciated by Turgot. He was deflected from his purpose by his enthusiasm for the theory of animism—a lapse into the methods of Cartesian scholasticism that was fatal to a consistent exposition of the Newtonian method which Turgot had introduced into the study of mankind. If Tylor had not indulged in the speculation in animism that led him to accept the revival of this type of scholasticism by Bastian, he might have revolutionised the whole range of humanitarian studies, and have achieved in ampler measure what Lecky claimed for the great teachers of the seventeenth century, "destroying the old prejudices, dispelling illusions, rearranging the various parts of our knowledge, and altering the whole scope and character of our sympathies."

Air Conditioning in Industry.

By N. E. JACKSON.

AIR conditioning, as the term implies, is the treatment of air necessary to give certain conditions of heating, cooling, moistening, or drying of air contained in a given space. It may be more exactly defined as the application of scientific principles and engineering practice for the obtaining of specified and predetermined physical effects upon materials, human beings, or the atmospheric conditions in buildings, by treatment with air the temperature, humidity, and purity of which is definitely controlled. This treatment must, however, only be regarded as a means of securing a certain objective, either physiological effects on human beings, or physical effects on materials.

The general properties of air are well known. It should, however, be clearly understood that air is capable of very extensive treatment, such as

heating and cooling, humidifying and dehumidifying. Its avidity for moisture is considerable; the higher its temperature, the more water vapour it is capable of absorbing. Thus at a temperature of 45° F., one cubic foot of air when saturated holds in suspension 3.44 grains of moisture. At 100° F., one cubic foot of saturated air holds 19.98 grains of moisture in suspension.

Air conditioning is resorted to in a great many important industries which require special atmospheric conditions for the carrying out of some of the many processes involved. A few of its applications are enumerated below.

ARTIFICIAL SILK.

In this more recent and highly specialised branch of the textile field, correct atmospheric