and $H^2_2O^{18}$: the effect of the O^{18} isotope is opposite in sign from that of H^2, and the measurement of the density and refractivity gives the complete isotopic composition (H^1, H^2, O^{16}, O^{18}) of a sample of water. The mutarotation of *α-d*-glucose in heavy water shows that the displaceable hydrogen atom of the sugar is immediately replaced by H^2 from the water, and the mutarotation is due to a change in which the double bond in a carbonyl group, =C=O, is replaced by a ring formed by the migration of a hydrogen atom[11].

By the interaction of heavy water with magnesium nitride, ammonias in which the hydrogen atoms are predominatingly H^2 (deutero-ammonias) are produced, which have higher melting points, boiling points and latent heats than ordinary ammonia[12].

Further experiments on the physiological effects of heavy water[13] show that the filaments of *Spirogyra* in water of specific gravity 1·000061 are characterised by lack of movement, absence of abscission or cell disjunction, and greater longevity. The usual effect with ice and steam water was confirmed[14]. The results suggest a stabilising action of water containing H^2, perhaps an effect on the colloids in the organism, the water bound in such colloids being known to be denser than free water. A slightly higher *p*H (as determined with bromthymol blue) for this sample of water was found. In other experiments[15], decreased enzyme activity and fermentation in isotope water, a more extensive spread of *Oscillatoria* (perhaps due to a *p*H of 6·77 as determined by the glass electrode), and the following results with *Spirogyra nitida* were found: a representative filament of 31 cells in isotope water had 43 cells after 6 days, of which 3 were dead; a filament of 37 cells in ordinary water showed no cell division at the end of 6 days and 20 cells died; in ice water renewed twice daily, a filament of 50 cells showed 15 abnormal at the end of five days, whilst the filament in freshly condensed water renewed twice daily showed all its 50 cells dead or shrunken in the same period; the control filament (pond water) had 47 cells initially and 64 normal cells after six days.

[1] Cf. A. and L. Farkas, NATURE, **132**, 894, Dec. 9, 1933.
[2] NATURE, **132**, 675, Oct. 28, 1933; cf. Polanyi and Horiuti, *ibid.*, 819, Nov. 25.
[3] cf. Collie, NATURE, **132**, 568, Oct. 7, 1933.
[4] *J. Amer. Chem. Soc.*, **55**, 4330; 1933.
[5] *J. Amer. Chem. Soc.*, **55**, 5058; 1933.
[6] Selwood and Frost, *J. Amer. Chem. Soc.*, **55**, 4335; 1933.
[7] NATURE, **132**, 536, Oct. 7, 1933.
[8] Taylor, Caley and Eyring, *J. Amer. Chem. Soc.*, **55**, 4334; 1933.
[9] Selwood and Frost, *J. Amer. Chem. Soc.*, **55**, 4335; 1933. Lewis and Macdonald, *ibid.*, 4730. Lewis, Olson and Maroney, *ibid.*, 4731; Lewis and Luten, *ibid.*, 5062.
[10] Crist, Murphy and Urey, *J. Amer. Chem. Soc.*, **55**, 5060; 1933. Lewis and Luten, *ibid.*, 5061.
[11] Pascu, *J. Amer. Chem. Soc.*, **55**, 5056; 1933.
[12] Taylor and Jungers, *J. Amer. Chem. Soc.*, **55**, 5057; 1933.
[13] Barnes, *J. Amer. Chem. Soc.*, **55**, 4332; 1933.
[14] NATURE, **132**, 536, Oct. 7, 1933.
[15] Barnes and Larson, *J. Amer. Chem. Soc.*, **55**, 5059; 1933.

Ernst Haeckel (1834-1914)

By PROF. E. W. MACBRIDE, F.R.S.

THE career of Prof. Ernst Heinrich Haeckel, the centenary of whose birth falls on February 16, belongs to the heroic stage of the history of the theory of evolution. In 1862, at the early age of twenty-eight, he was appointed to the chair of zoology in the University of Jena, a post which he held until his death in 1914.

Haeckel's life bears a strong resemblance to that of Huxley, for like Huxley his life's task was propaganda in favour of the theory of evolution against the then prevalent theory of the origin of species by a series of supernatural interpositions of the Divine Being. Like Huxley too, he was an ardent advocate of the animal origin of the human race. But there were marked differences between the two men; Haeckel was a harder hitter than Huxley, and withal a much more reckless one, since he was apt to make wild statements on the basis of insufficient data, as, for example, when he stated that if there were a line to be drawn between animals and men, the lower races must be included amongst the apes. The most recent anthropological studies seem to indicate that in the essential make-up of their minds the most primitive men are very like ourselves: the data and presuppositions from which they start are different and so are their customs and traditions, but granted these postulates the conclusions at which they arrive are natural enough. But on the whole, Haeckel was a sounder biologist than Huxley: whilst he embraced with enthusiasm Darwin's arguments about natural selection, he was never deceived into thinking that the mere survival of some and the death of others could account for progressive evolution: he saw quite clearly that the vital question was the origin of the 'variations' which distinguished the survivor from his less fortunate brother, and in this matter he followed Lamarck. When he popularised his views in his famous "History of Creation" he dedicated the work to "Jean Lamarck and Charles Darwin".

Haeckel excelled Huxley also in the amount of actual zoological work which he accomplished. Thus he wrote a descriptive monograph of the Radiolaria collected by H.M.S. *Challenger*, giving the characters of no less than 3,600 new species. This work occupied him for ten years. He also monographed the calcareous sponges, but the greatest task which he attempted was to sketch, assuming the truth of the evolution theory, the actual course which evolution had pursued in producing modern plants and animals. His conclusions were embodied in his "Allgemeine Morphologie", of which the "History of Creation" may be regarded as a popular edition. Of course, the state of zoological and botanical knowledge at the time that these books were written was far too incomplete to permit of any but the vaguest sketches of the course of evolution, but there can be nothing but admiration for Haeckel's bold adventure. In the circumstances, it was the right course to pursue: it summarised pre-existing knowledge and provided both a foundation and a framework for future work, and some of the most important and fundamental of Haeckel's ideas have stood the test of time. Thus he divided living beings into Animals, Plants and Protista; regarding the last group, which included the simple unicellular organisms, as the common seed-bed from which both animals and plants have sprung. The discovery of green ciliates like some species of *Stentor* and *Vorticella*, and of colourless carnivorous Dinoflagellates which devour young oysters, in addition to the ordinary brown species which live like brown seaweeds, has more than justified Haeckel's classification.

Haeckel's most far-reaching hypothesis was, however, his famous 'biogenetic law'. He invented the terms phylogeny and ontogeny—the first, according to him, designated the palæontological history of the race, the second the history of the development of the individual from the egg to the adult condition. The law connecting these two was the 'Biogenetic fundamental principle': stated in his own words, it ran thus: "Ontogeny is a short and quick repetition, or recapitulation of Phylogeny determined by the laws of inheritance and adaptation". Haeckel pointed out that if this principle be admitted, there is some hope of tracing, in outline at least, the actual course of evolution; whereas if we were to confine ourselves to palæontological evidence, we should only see glimpses of evolution in special cases. The past history of the Vertebrata may be traced from fossils with considerable exactitude since vertebrates possess an internal skeleton which is often preserved and which gives in its scars and processes, evidence of the muscles which once accompanied it and consequently of the actions and habits of the animal which possessed the skeleton. The external skeleton of extinct Crustacea which clings tightly to every protuberance of the body, also reveals a good deal about the activities of its former possessor. But what scanty light do the shells of extinct Mollusca and the tests of ancient Echinoderms throw on the internal structure of their owners! Who would dream from their evidence that radiate Echinoderms were derived from bilateral ancestors?

In our judgment the formulation of this biogenetic law was the greatest service which Haeckel did to the science of zoology, and the more we reflect on it the greater the service will appear. Haeckel was, of course, aware that these reminiscences of ancestral life could be modified, blurred or occasionally completely obscured. He knew that for the elucidation of life-histories only the comparative method would avail; and just as in the comparison of two ancient documents the truth will shine through the errors peculiar to each one, so with life-histories.

The acceptance of this law as giving a picture of evolution drew with it certain conclusions as to the causes of evolution. Haeckel described variations as 'adaptations'. There were, he said, two classes of these, namely, (1) small ones which were the result of habits and which were *transmitted to posterity with greater certainty the longer they had lasted* (this is pure Lamarckian doctrine), and (2) great adaptations which appeared suddenly and the causes of which were unknown to us, though in some cases they appeared to have originated with intra-uterine influences. These latter are now, of course, called mutations, and it was the first category alone which Haeckel believed to be significant for evolution, for the growth of the individual suggests that evolutionary growth was slow, functional and continuous.

The biogenetic law proved a tremendous stimulus to zoological research. Of course, it encountered opposition; its enthusiastic votaries desired, like all enthusiasts, to reach the 'promised land' at once: they failed to realise that ancestral history could only be elucidated by prolonged, careful and comparative research. They could not deny themselves the pleasure of making wild guesses as to ancestry based on the study of some one life-history and in time 'Haeckelismus' became a term of reproach. But the principle was essentially sound; from all opposition it emerged triumphant: it has been transferred to ever wider fields and has been found to throw light even on the development of the mental life of man. A certain school of biologists at the present day affects to denigrate it and that for obvious reasons, for if it is sound then one thing is certain, mutations have played no part in evolution. But ancestral history stands out so clearly in some life-histories that none but the wilfully blind can deny its presence. Amongst the Ctenophora, for example, there are two aberrant forms, *Tjafiella* and *Cœloplana*. The first resembles a sponge, the second a flat-worm; yet both begin their free existence as typical little Ctenophores, globular in form with 8 meridional bands of cilia radiating from the upper pole. But if ancestral history is the foundation of some life-histories is it not reasonable to assume that it lies at the base of all?

The real originator of the theory that evolution proceeded by jumps and that "Discontinuity in variation was the cause of discontinuity in species" was the late Dr. Bateson. In his first and best work on the development of *Balanoglossus* he found himself driven to the conclusion that Echinoderms and Vertebrates had radiated from a common stock and his faith in 'recapitulation' failed him, although it is interesting to record that this conclusion has been sustained by recent research and that from the most unlikely quarter, namely, biochemistry. He then made "*il gran rifiuto*" and fell back on sports and monstrosities as the material of evolution. At the meeting of the Zoological Congress in Cambridge in 1898, Bateson put forward his views. Haeckel was present at the meeting and some sentences of his still linger in our memory. He said that if views like these are to be accepted, "Kehren wir lieber zu Moses zurück".