

metallic dome is not in any way connected metallically with the ground. The rareness of thunderstorms is accounted for by the presence of the central crater, the smoke and hot vapour of which act as a lightning conductor on a large scale.

The climate in the neighbourhood of the mountain is of a very varied nature. Except in the summer months the summit is always covered with snow, and it is therefore very cold. At the base, on the other hand, the weather is warm, and the vegetation varies from tropical to arctic species. On ascending the mountain one meets with cacti, oranges, olives, vines, corn, ferns, astragal, chestnut trees and pine trees, up to a height of about 2000 metres. At a higher altitude only rock, volcanic sand, and snow are found.

After an outbreak of the volcano it is natural to suppose that the snow is generally melted by the hot lava. It is of interest, however, to note that a layer of volcanic cinders has been known to protect the snow from lava at a temperature of about 1000°, so that when covered by it the snow was but slightly melted, and the lava formed a black covering in contrast to this white background.

The view from the summit of Mount Etna is described as most magnificent, extending nearly 200 kilometres in all directions. This is due to the fact that the air at this height is reduced to a third of its density, and is of extreme transparency.

FRITZ MÜLLER.

THE death of Dr. Fritz Müller, which took place on May 21 at Blumenau, in South Brazil, has inflicted upon science a loss, the importance of which needs no pointing out. Although the greater part of his life was passed at a distance from the centres of scientific thought, and his natural modesty and self-effacement left him indifferent to his own fame, it has long been recognised that the qualities of observation and interpretation which drew from Darwin the title of "the prince of observers," have earned him a position as one of the greatest and most original naturalists of the century.

Johann Friedrich Theodor Müller was born on March 31, 1822, at Windisch-Holzhausen, in Thuringia, where his father was pastor. After receiving his schooling at Erfurt, he began the study of pharmacy, but shortly afterwards went to Berlin as a pupil of his distinguished namesake, Johannes Müller, the zoologist. As soon as he had taken his doctor's degree, for which he wrote a thesis on the leeches of the neighbourhood of Berlin, he settled at Erfurt as a teacher of science. The occupation, however, proved uncongenial, and he again changed his studies, and turned to medicine, with a view to becoming a ship's surgeon, and thus gaining opportunities for travel and for zoological work in foreign countries. During this early period he began gradually to make a name for himself in science by the occasional publication of various morphological and descriptive papers on leeches and crustacea.

In 1852 the liberal character of his political views brought about a crisis which led to his leaving Germany and betaking himself to Blumenau, on the river Itajahy, just outside the limits of the tropics, where, his education and tastes notwithstanding, he settled down to the occupation of a farmer. Henceforward Brazil was his home, and to this fact and the freedom it brought from the limits set to observation by travel and temporary residence is largely due his distinctive position among naturalists. Under less favourable conditions much of his work, particularly on morphological subjects and on matters involving experiment such as the hybridisation of plants, must have been impracticable. Nevertheless, his expatriation put an end to research for some years, until an appointment as teacher of mathematics at the

gymnasium of Desterro, on the island of Sta. Catharina, gave him the wished-for opportunity, and he began assiduously to study the invertebrates of the Brazilian coast, and to overcome the difficulties which the absence of a properly-equipped zoological station and his remoteness from literature and fellow-workers entailed.

From 1857 onwards he published a rapid succession of papers, chiefly in *Wiegmann's Archiv*, on cœlenterrates, annelids, and especially crustacea, with the transformations of which he was much occupied. Development, in fact, had at all times a great attraction for him, and he was the first to observe and describe the larval stages of a brachiopod and of *Squilla*. The material for several memoirs was furnished by parasitic forms. He described an anemone, *Philomedusa*, parasitic on a medusa, and made careful studies of such degraded crustacea as *Entoniscus* and *Sacculina*, for the latter of which, together with its allies, he formed the family Rhizocephalidæ. During this period his work was almost entirely concerned with morphological subjects, and it was not until the "Origin of Species" had brought a new interest and significance to the relations between structure and bionomics that he devoted close attention to field observation.

He must have become acquainted with the "Origin" very soon after its publication, and probably received a copy of it from his younger brother and devoted correspondent, Hermann Müller of Lippstadt. His initial attitude towards the book appears to have been critical rather than receptive, for he admits that it was an observation of his own which gave him the first decided impulse in its favour. But he was not long in finding that he could unreservedly accept its principles and devote his energies to their support; and the theory of natural selection gave a definite direction to the whole of his subsequent work.

The observation which determined his adherence to the theory of evolution was the discovery of the nauplius-larva of *Penæus*, a genus of prawns. Important as it is from its bearing on the phylogeny of the crustacea, in which malacostracous nauplius was previously unknown, and its influence on Müller himself, it has not even yet been fully confirmed. Müller succeeded in breeding the protozoæa-stage from his nauplius, but had to build up the further steps in the development from a series of captured examples. Here was room for error, and his account consequently met with a criticism which induced him, in spite of an expressed dislike to going twice over the same ground, to return to the defence of his observations in 1878. Four years later Prof. W. K. Brooks succeeded in rearing *Penæus* from a protozoæa, "identical with that developed by Fritz Müller," but the assumption involved in this statement was such as to prevent the matter from being regarded as settled, and Müller's account, though presumptively correct, is still accepted with reserve by some carcinologists.

The philosophic bent of his mind soon led Müller to recognise the possibility of testing the principles of evolution by applying them towards the building-up of the phylogeny of some group of animals, and ascertaining how far the theoretical results obtained were reconcilable with the observed facts of development. The idea was put into practice for the crustacea in a little book published in 1865, the well-known "Für Darwin," which had a great success in spite of its technical character and limited scope. This success was probably due not merely to the value of its accounts of crustacean development, which embody the main results of Müller's own researches, and the then novel support which the deductive argument brought to evolution, but also to the brilliant simplicity of a title which disclosed nothing beyond the fact of his advocacy and would have served even better to cover the whole of his subsequent writings. At that time the principle of evolution itself was at stake,

and the book is essentially an argument for it, rather than for natural selection, in support of which as distinct from other suggested agencies it advances comparatively little.

Its publication naturally aroused Darwin's interest; he quoted freely from it in the later editions of the "Origin," and arranged for its appearance in an English translation. This was made by Mr. W. S. Dallas, and published in 1869 under the somewhat less forcible title of "Facts and Arguments for Darwin." It materially increased the reputation which Müller had gained in this country during the preceding twelve years by the appearance in the "Annals and Magazine of Natural History" of translations or abstracts of his chief papers, also from the pen of Mr. Dallas.

The most important result, however, of "Für Darwin" was that it led Darwin to address to Fritz Müller in August 1865, the first of the long series of letters which passed between the two naturalists. Mr. Francis Darwin has put on record his recollection of the pleasure which his father took in this correspondence, and his impression that of all unseen friends Müller was the one for whom his father had the strongest regard. Closely in touch with nature as Müller was, his was exactly the adherence which was most welcome to Darwin, who so directly recognised the affinity in character and mental outlook between himself and his correspondent that, in asking for Müller's opinion on pangenesis, he wrote: "I value your opinion more than that of almost any one. . . I feel sure that our minds are somewhat alike."

Some of the letters written by Müller were sent for publication to NATURE; from these as well as from the references in Darwin's published correspondence and books, particularly "The Forms of Flowers" and "Cross and Self-Fertilisation of Plants," some idea can be formed of the abundance of new and interesting observations on all sorts of subjects, largely botanical, which Müller made and communicated. These letters, which drew from Darwin the exclamation: "Heaven knows whether I shall ever live to make use of half the valuable facts which you have communicated to me," show, even better than his papers, Müller's insight into and sympathy with Darwin's work, and his consequent tendency to be always on the look-out for any peculiarity of structure or habits that could be interpreted by natural selection.

Thus, when in the controversy as to the existence of the insect required, *ex hypothesi*, to reach the nectary of *Angræcum*, it was contended that no existing moth possessed a proboscis of the necessary length—about eleven inches—Müller entirely disposed of the contention by forwarding the proboscis belonging to an undetermined Brazilian *Sphinx*, of the length required, to his brother, who described and figured it in these columns.

In 1867 the increasing influence of the Jesuits compelled Müller to leave Desterro, and he returned to the occupation of a farmer, a change which brought his work on marine zoology to an end. At this time he was appointed naturalist to the Brazilian Government, and somewhat modified the range of his studies, occupying himself with entomology and botany, and applying a more systematic attention to bionomics and field observation. Although often looked upon as mainly an entomologist, he published nothing on insects during the first thirty years of his career. In 1873, however, he began a series of papers on Termites in the *Jenaische Zeitschrift*; these contain some of his most brilliant conceptions in the theories put forward as to the existence and function of the supplementary reproductive forms and the uselessness of the true imagos, as well as in the comparison of the two kinds with cleistogamic and perfect flowers. Although the facts at his disposal were insufficient to enable him to confirm his theories, they formed the foundation on which Prof. Grassi has since successfully built, and which he has appropriately

acknowledged by the dedication of his monograph to his predecessor.

Fritz Müller's most familiar entomological work is certainly that on mimicry. The original theory of Bates failed to suggest any explanation of the most striking class of resemblances found among butterflies, those subsisting between pairs or among groups of what are regarded as protected forms, and was open to criticism on several points for want of evidence. Bates, it must be recollected, did not elaborate it on the Amazons, but after his return to England, when all opportunity of specially directed observation had ceased for him, Müller first dealt with the possibility of the origin by gradual stages of a mimetic from a non-mimetic pattern, a point left so little treated as to have invited scepticism; but his work, though sound in principle, suffered from a want of familiarity with the range of form in the genera discussed, which only the resources of a museum could remedy, and the idea has been recently worked out more exhaustively by Dr. Dixey.

In 1879 Müller published in "Kosmos," to which he had been a regular contributor from the first, the well-known hypothesis framed to supplement that of Bates, and based on the assumption that a bird learns to recognise and avoid an unpalatable species of butterfly as the outcome of a series of experiments. The toll thus taken must stand in relation to the number of birds and not of butterflies, and would therefore be distributed over two or more species of the latter by their acquisition of a common appearance, a fraction only of the loss falling on each component of such a group.

The "Müllerian theory," though destined to perpetuate its author's name, is scarcely typical of his work in so far as it is an ingenious speculation, not dependent on direct observation, but one which could have been evolved by a naturalist who had never seen a living example of the insects it deals with. Still, it remains the first and only serious attempt to bring an intractable class of facts within the scope of natural selection, and, even if it should be ultimately superseded, it will have immensely advanced the study of these wonderful resemblances.

The paper containing Müller's article was sent by Darwin to Prof. Meldola, then Secretary of the Entomological Society of London, who recognised its importance, and at once published a translation. The theory, however, met with much opposition, including that of Bates himself, then somewhat past the reception of new ideas, but to its author's great gratification it found a warm supporter in Dr. Wallace, whose adhesion involved the abandonment of an earlier view that these resemblances were due to unknown local conditions. Three years later this view was strenuously combated by Müller in an important but untranslated, and therefore less familiar, article. To accept its main argument, that these likenesses result from some process of visual selection—and it has never been seriously answered—does not compel belief in a destructive process. Though Müller suggests no alternative in his paper, he appears to have held and privately put forward the idea that another factor, that of direct selection or segregation on the part of the insects themselves, might play some part. He paid a large amount of attention to the scent-tufts, odours and other means of recognition in butterflies, and at a somewhat earlier period had so far expressed his views that we find Darwin writing to him in 1871 ("Life and Letters of Charles Darwin," iii. p. 151): "Would you object to my giving some such sentence as follows: 'F. Müller suspects that sexual selection may have come into play, in aid of protective imitation, in a very peculiar manner, which will appear extremely improbable to those who do not fully believe in sexual selection. It is that the appreciation of certain colour is developed in those species which frequently behold other species thus ornamented.'" Granted that this was a somewhat

fanciful speculation, it is at least significant that it should have presented no improbability to the mind of an observer before whom the insects concerned were constantly present as a living reality.

The work on mimicry was brought to a close with the account, published in 1883, of the torn wings collected from specimens of an inedible butterfly, *Acraea thalia*, in order to show that a protected insect was not immune from tentative attacks on the part of birds. Still, even if the evidence thereon be regarded as conclusive, it scarcely indicates the difference in amount between the attacks made on protected and unprotected species respectively, which must exist under Müller's hypothesis. And in view of the doubts which have been expressed by competent observers as to the prevalence of butterfly-destruction on the part of birds, the subject calls for further and more exhaustive investigation. Since Müller's work, little progress has been made on the study of mimicry by observations on the living forms.

Amongst the many other entomological subjects investigated by him are cases of dimorphism in fig-insects and in gnats, in a species of which he found two kinds of females, one large-eyed and honey-sucking, the other small-eyed and blood-sucking; the case-making of Phryganeidae and the development, in some cases very remarkable, of several species of aquatic insects. As recently as 1895 he published in the *Transactions* of the Entomological Society of London a paper on the metamorphoses of an aquatic fly, the material for which, however, had been worked out some fourteen years previously, when the drawings were made. These are, perhaps, the best published examples of his skill as a draughtsman.

In botany Müller's work, like that of his brother, the author of "Die Befruchtung der Blumen," deals mainly with the fertilisation of plants, and includes a number of important observations on heterostylism, hybridisation and self-sterility, many of which are recorded in Darwin's "Animals and Plants under Domestication" and "Cross and Self-fertilisation of Plants." The experimental results obtained, e.g. in the fertilisation of orchids, are of great interest; in a series of cases he was able to establish a progressive gradation in self-sterility from species in which the flower was sterile to its own pollen but not to that taken from other flowers on the same plant, up to those in which entire fertility was only to be obtained by crossing, the pollen of a different species being prepotent. Most remarkable of all, in certain species the pollen of a flower was found actually to have a destructive effect upon its own stigma.

His later years were mainly given over to botanical studies, but the period was clouded with a succession of misfortunes which he bore courageously, not losing his interest in research, although his activity was diminished. For him science meant the advancement of knowledge, and he looked for no practical benefits for himself from it. Assuredly they did not come unsought. As far back as 1880 he suffered gravely from the destruction of his property by a flood, a loss which drew from Darwin a touching expression of sympathy and a desire to aid. At a later period the Brazilian Government, with singular illiberality, deprived him of his post without pensioning him, and left him in straitened circumstances; and as recently as 1894 he was imprisoned by rebels and tried by court-martial. In the same year the death of his wife took place, but the bereavement, heavy as it was, did not affect him so deeply as did the loss of a beloved daughter, herself an excellent observer, who, at eleven years of age, discovered the circumnutation of *Linum*. She died at Berlin, and the blow deprived her father for a long time of all desire for work. But his indomitable enthusiasm overcame even this trouble, and his researches were carried on up to the last year of his life.

To call Müller by Darwin's happily-bestowed title is to recognise not merely the energy, perseverance and

capacity for observation which he brought to his work, but also the discrimination which led him to the choice of subjects for study and the closely-reasoned and philosophic interpretation of his results. If his name is not associated with any marked advance in thought, except on one or two special questions connected with natural selection, it is because he found his intellectual faith in the theory which he set himself to developing and strengthening. He was content, in fact, to assist in the building of the structure of which another was architect, and in this task his services have been great. It may be questioned whether any other naturalist, save Darwin himself, has given the world so large and original a mass of observations of the kind by which natural selection has been most strongly supported.

To take a just and comprehensive survey of his labours is by no means easy. His papers are scattered through many journals, and a full bibliography of them is as yet wanting; even the list, down to 1883, given in the "Royal Society Catalogue of Scientific Papers" is incomplete, omitting as it does all his contributions to "Kosmos." Moreover, they cover a wider range than most naturalists take for their province, and yet are far from containing the whole of his results. Not a few of his notes have been made public by the friends to whom he communicated them with characteristic generosity; others still lie buried in his letters and memoranda. And a reference to such papers as those on mimicry makes it plain that but a part of his published observations have found their way into common scientific knowledge, and many still wait to be incorporated into the fabric of biology.

More than five-and-twenty years have passed since Darwin wrote to Müller: "I earnestly hope that you will keep notes of all your letters, and that some day you will publish a book, 'Notes of a Naturalist in S. Brazil,' or some such title." But the idea did not attract, and the wish, though echoed by many friends, was destined to remain unfulfilled. One can therefore but express the hope that, now that his labours are ended, such a record of them may be given to the world as shall form a worthy memorial of so earnest and single-minded a lover of nature.

W. F. H. B.

NOTES.

WE invite attention to the change of address of the publishers of NATURE, announced in our advertisement columns. After Saturday next, October 9, all communications for the editor of NATURE should be sent to St. Martin's Street, London, W.C.

WE regret to announce that Dr. Charles Smart Roy, F.R.S., of Trinity College, Professor of Pathology in the University of Cambridge, died on Monday night, at the age of forty-three years.

THE Accademia dei Lincei have just elected Prof. G. H. Darwin, F.R.S., and the Right Hon. G. J. Goschen, M.P., F.R.S., foreign members of the Academy.

IT is stated in the *Athenæum* that the well-known Dr. Adolf Harnack is engaged on a "History of the Prussian Academy of Sciences," which is to appear in the year 1900, the two hundredth anniversary of its foundation.

THE annual address of the President of the Royal Photographic Society will be delivered at the meeting of the Society on Tuesday next, October 12. The presentation of the medals will take place on the same evening.

THE *Geological Magazine* makes the following announcement with reference to the forest-bed of the Norfolk coast:—This interesting deposit, so rich in organic remains, has been care-