of a gnat or butterfly could be developed from a powerfully mandibulate type like the Orthoptera, or even from the Neuroptera. M. Brauer has recently suggested that the interesting genus *Campodea* is, of all known existing forms, that which probably most nearly resembles the parent insect stock. He considers that the grub form of larva is a retrograde type, in which opinion I am unable to concur, though disposed to agree with M. Brauer on the first point. M. Brauer in coming to this conclusion relies partly on geological considerations; partly on the fact that larvæ, more or less resembling *Campodea*, are found among widely different groups of insects. I think there are other considerations which offer considerable support to this view. No one, so far as I know, has yet attempted to explain, in accordance with Mr. Darwin's views, such a life history as that, for instance, of a butterfly, in which the mouth is first mandibulate and then suctorial. A clue to the difficulty might, I think, be found in the distinction between developmental and adaptive changes, to which I called the attention of the Society in a previous memoir. The larvæ of insects are by no means mere stages in the development of the perfect animal. On the contrary, they are subject to the influence of Natural Selection, and undergo changes which have reference entirely to their own requirements and condition. It is evident then that, while the embryonic development of an animal in the egg gives us an epitome of its specific history, this is by no means the case with species in which the immature forms have a separate and independent existence. Hence, if an animal when young pursues one mode of life, and lives on one kind of food, and subsequently, either from its own growth in size and strength, or from any change of season, alters its habits or food, however slightly, immediately it becomes subject to the action of distinct forces; Natural Selection affects it in two different, and it may be very distinct, manners, gradually leading to differences which may become so great as to involve an intermediate period of change and quiescence.

There are, however, peculiar difficulties in those cases in which, as among the Lepidoptera, the same species is mandibulate as a larva and suctorial as an imago. From this point of view, however, *Campodea* and the *Collembola* (*Podura*, &c.) are peculiarly interesting. There are among insects three principal types of mouth, firstly, the mandibulate, secondly, the suctorial, and thirdly, that of *Campodea*, and the *Collembola* generally, in which the mandibles and maxillæ are attached internally, and though far from strong, have some freedom of motion, and can be used for biting and chewing soft substances. This type is intermediate between the other two. Assuming that certain representatives of such a type found themselves in circumstances which made a suctorial mouth advantageous, those individuals would be favoured by Natural Selection in which the mandibles and maxillæ were best calculated to pierce or prick, and their power of lateral motion would tend to fall into abeyance, while, on the other hand, if powerful masticatory jaws were an advantage, the opposite process would take place.

There is yet a third possibility—namely, that during the first portion of life the power of mastication should be an advantage, and during the second that of suction, or *vice versâ*. A certain kind of food might abound at one season and fail at another; might be suitable for the animal at one age and not at another: now in such cases we should have two forces acting successively on each individual, and tending to modify the organisation of the mouth in different directions. It will not be denied that the ten thousand variations in the mouth parts of insects have special reference to the mode of life, and are of some advantage to the species in which they occur. Hence no believer in Natural Selection can doubt the possibility of the three cases above suggested, and the last of which seems to explain the possible origin of species which are mandibulate in one period of life and not in another. The change from the one condition to the other would no doubt take place contemporaneously with a change of skin. At such times we know that, even when there is no change of form, the temporary softness of the organs often precludes the insect from feeding for a time, as, for instance, is the case in the silkworm. When, however, any considerable change was involved, this period of fasting would be prolonged, and would lead to the existence of a third condition, that of pupa, intermediate between the other two. Since other changes are more conspicuous than those relating to the mouth, we are apt to associate the pupa state with the acquisition of wings, but the case of the Orthoptera (grasshoppers, &c.) is sufficient proof that the development of wings is perfectly compatible with continuous activity. So that in reality the necessity for rest is much more intimately connected with the change in the constitution of the mouth, although in many cases no doubt the result is accompanied by changes in the legs, and in the internal organisation. It is, however, obvious that a mouth like that of a beetle could not be modified into a suctorial organ like that of a bug or a gnat, because the intermediate stages would necessarily be injurious. Neither, on the other hand, for the same reason could the mouth of the Hemiptera be modified into a mandibulate type like that of the Coleoptera. But in *Campodea* and the *Collembola* we have a type of animal closely resembling certain larvæ which occur both in the mandibulate and suctorial series of insects, and which possesses a mouth neither distinctly mandibulate nor distinctly suctorial, but constituted on a peculiar type capable of modification in either direction by gradual changes without loss of utility.

If these views are correct, the genus *Campodea* must be regarded as a form of remarkable interest, since it is the living representative of a primæval type from which not only the *Collembola* and *Thysanura* but the other great orders of insects have all derived their origin.

CHARLES BABBAGE

DIED THE 20TH OF OCTOBER, 1871

THERE is no fear that the worth of the late Charles Babbage will be over-estimated by this or any generation. To the majority of people he was little known except as an irritable and eccentric person, possessed by a strange idea of a calculating machine, which he failed to carry to completion. Only those who have carefully studied a number of his writings can adequately conceive the nobility of his nature and the depth of his genius. To deny that there were deficiencies in his character, which much diminished the value of his labours, would be useless, for they were readily apparent in every part of his life. The powers of mind possessed by Mr. Babbage, if used with judgment and persistence upon a limited range of subjects, must have placed him among the few greatest men who can create new methods or reform whole branches of knowledge. Unfortunately the works of Babbage are strangely fragmentary. It has been stated in the daily press that he wrote eighty volumes; but most of the eighty publications are short papers, often only a few pages in length, published in the transactions of learned societies. Those to which we can apply the name of books, such as "The Ninth Bridgewater Treatise," "The Reflections on the Decline of Science," or "The Account of the Exposition of 1851," are generally incomplete sketches, on which but little care could have been expended. We have, in fact, mere samples of what he could do. He was essentially one who began and did not complete. He sowed ideas, the fruit of which has been reaped by men less able but of more thrifty mental habits.

It was not time that was wanting to him. Born as long ago as the 26th of December, 1792, he has enjoyed a

working life of nearly eighty years, and, though within the last few years his memory for immediate events and persons was rapidly decaying, the other intellectual powers seemed as strong as ever. The series of publications which constitute the real record of his life commenced in 1813 with the preface to the Transactions of the Analytical Society, a small club established by Babbage, Herschel, Peacock, and several other students at Cambridge, to promote, as it was humorously expressed, the principles of pure D-ism, that is, of the Leibnitzian notation and the methods of French mathematicians. Until 1822 Mr. Babbage's writings consisted exclusively of memoirs upon mathematical subjects, which, however little read in the present day, are yet of the highest interest, not only because they served to awaken English mathematicians to a sense of their backward position, but because they display the deepest insight into the principles of symbolic methods. His memoir in the "Cambridge Philosophical Transactions" for 1826, "On the Influence of Signs in Mathematical Reasoning" may be mentioned as an admirable example of his mathematical writings. In this paper, as in many other places, Mr. Babbage has expressed his opinion concerning the wonderful powers of a suitable notation in assisting the human mind.

As early as 1812 or 1813 he entertained the notion of calculating mathematical tables by mechanical means, and in 1819 or 1820 began to reduce his ideas to practice. Between 1820 and 1822 he completed a small model, and in 1823 commenced a more perfect engine with the assistance of public money. It would be needless as well as impossible to pursue in detail the history of this undertaking, fully stated as it is in several of Mr. Babbage's volumes. Suffice it to say that, commencing with 1,500*l.*, the cost of the Difference Engine grew and grew until 17,000*l.* of public money had been expended. Mr. Babbage then most unfortunately put forward a new scheme for an Analytical Engine, which should indefinitely surpass in power the previously-designed engine. To trace out the intricacies of negotiation and misunderstanding which followed would be superfluous and painful. The result was that the Government withdrew all further assistance, the practical engineer threw up his work and took away his tools, and Mr. Babbage, relinquishing all notions of completing the Difference machine, bestowed all his energies upon the designs of the wonderful Analytical Engine. This great object of his aspirations was to be little less than the mind of a mathematician embodied in metallic wheels and levers. It was to be capable of any analytical operation, for instance solving equations and tabulating the most complicated formulæ. Nothing but a careful study of the published accounts can give an adequate notion of the vast mechanical ingenuity lavished by Mr. Babbage upon this fascinating design. Although we are often without detailed explanations of the means, there can be little doubt that everything which Mr. Babbage asserted to be possible would have been theoretically possible. The engine was to possess a kind of power of prevision, and was to be so constructed that intentional disturbance of all the loose parts would give no error in the final result.

Although for many years Mr. Babbage entertained the intention of constructing this machine, and made many preparations, we can hardly suppose it capable of practical realisation. Before 1851 he appears to have despaired of its completion, but his workshops were never wholly closed. It was his pleasure to lead any friend or visitor though these rooms and explain their contents. No more strange or melancholy sight could well be seen. Around these rooms in Dorset Street were the ruins of a life time of the most severe and ingenious mental labours perhaps ever exerted by man. The drawings of the machine were alone a wonderful result of skill and industry; cabinets full of tools, pieces of mechanism, and various contrivances for facilitating exact workmanship, were on every side, now lying useless.

Mr. Babbage's inquiries were not at all restricted to mathematical and mechanical subjects. His work on the "Economy of Manufactures and Machinery," first published in 1832, is in reality a fragment of a treatise on Political Economy. Its popularity at the time was great, and, besides reprints in America, translations were published in four Continental languages. The book teems with original and true suggestions, among which we find the system of Industrial Partnerships now coming into practice. It is, in fact, impossible to overpraise the work, which, so far as it goes, is incomparably excellent. Having assisted in founding the Statistical Society of London in 1834, Mr. Babbage contributed to their Transactions a single paper, but as usual it was a model research, containing a complete analysis of the operations of the Clearing House during 1839. It was probably the earliest paper in which complicated statistical fluctuations were carefully analysed, and it is only within the last few years that bankers have been persuaded by Sir John Lubbock to recognise the value of such statistics, and no longer to destroy them in secret. In this, as in other cases, many years passed before people generally had any notion of the value of Mr. Babbage's inquiries; and there can be little doubt that, had he devoted his lofty powers to economic studies, the science of Political Economy would have stood by this time in something very different from its present pseudo-scientific form.

Perhaps the most admirable of all his writings was the Ninth Bridgewater Treatise, an unexpected addition to that well-known series, in which Mr. Babbage showed the bearing of mathematical studies upon theology. This is one of the few scientific works in which the consistency of natural laws with breaches of continuity is clearly put forth. That Power which can assign laws can set them aside by higher laws. Apart from all particular theological inferences, there can be no question of the truth of the views stated by Babbage; but the work is hardly more remarkable for the profundity of its philosophy than for the elevated and eloquent style in which it was written, although as usual an unfinished fragment.

Of all Mr. Babbage's detached papers and volumes, it may be asserted that they will be found, when carefully studied, to be models of perfect logical thought and accurate expression. There is, probably, not a sentence ever penned by him in which lurked the least obscurity, confusion, or contradiction of thought. His language was clear, and lucid beyond comparison, and yet it was ever elegant, and rose at times into the most unaffected and true eloquence. We may entertain some fear that the style of scientific writing in the present day is becoming bald, careless, and even defective in philosophic accuracy. If so, the study of Mr. Babbage's writings would be the best antidote.

Let it be granted that in his life there was much to cause disappointment, and that the results of his labours, however great, are below his powers. Can we withhold our tribute of admiration to one who throughout his long life inflexibly devoted his exertions to the most lofty subjects? Some will cultivate science as an amusement, others as a source of pecuniary profit, or the means of gaining popularity. Mr. Babbage was one of those whose genius urged them against everything conducive to their immediate interests. He nobly upheld the character of a discoverer and inventor, despising any less reward than to carry out the highest conception which his mind brought forth. His very failures arose from no want of industry or ability, but from excess of resolution that his aims should be at the very highest. In these money-making days can we forget that he expended almost a fortune on his task? If, as people think, wealth and luxury are corrupting society, should they omit to honour one of whom it may be truly said, in the words of Merlin, that the single wish of his heart was "to give them greater minds"?