tional supply of food. In the former case the embryo is more likely to survive; but, on the other hand, when the eggs are large, they cannot be numerous, and a multiplicity of germs is, in some circumstances, a great advantage. Even in the same species the development of the egg offers certain differences.*

The metamorphoses of insects depend then primarily on the fact that they quit the egg in a very early condition; many—as, for instance, flies and bees—before the thoracic segments are differentiated; others—as locusts, dragon flies, &c., after the formation of the legs, but before that of the wings.

We may now pass to the second part of the subject, that is to say, the sudden and abrupt instance of the changes which insects undergo. The development of an Orthopterous insect, indeed—say, for instance, of a grasshopper—from birth to maturity is so gradual, that but for the influence on our nomenclature exercised by the most striking changes which occur in insects of the Heteromorphous series, they would perhaps never have been classed as metamorphoses. But though the changes from the caterpillar to the chrysalis, as from the chrysalis to the butterfly, are apparently sudden and abrupt, this is in reality more apparent than real; the changes in the internal organs, though rapid, are in reality gradual; and even as regards the external form, though the metamorphosis may take only a few moments, this is but the change of outer skin—the drawing away, as it were, of the curtain; and the new form which then appears has been in preparation for days or, perhaps, weeks before.

Swammerdam, indeed, supposed (and his view was adopted by Kirby and Spence) that the larva contained within itself "the germ of the future butterfly, enclosed in what will be the case of the pupa, which is itself included in three or more skins, one over the other, that will successively cover the larva." This is a mistake; but it is true that, if a larva is examined shortly before it is full grown, the future pupa may be traced within it. In the same manner, if we examine a pupa which is about to disclose the butterfly, we find the future insect, soft indeed and imperfect, but still easily recognisable, lying more or less loosely within the pupa-skin.

One important difference between an insect and a vertebrate animal is, that whereas in the latter, as for instance in ourselves, the muscles are attached to an internal bony skeleton, in insects no such skeleton exists. They have no bones, and their muscles are attached to the skin. Hence the necessity for the hard and horny dermal investment of insects, so different from the softness and suppleness of our own skin. Moreover the result is, that without a change of skin a change of form is impossible. The chitine, or horny substance, forming the outside of an insect, is formed by a layer of cells lying beneath it, and, once secreted, cannot be altered. From this it follows that every change of form is necessarily accompanied by a change of skin. In some cases, as for instance in *Chloëon*, each change of skin is accompanied by a change of form, and thus the perfect insect is more or less gradually evolved. In others, as for instance in caterpillars, several changes of skin take place without any material alteration of form, and the change, instead of being spread over many, is confined to the last two moults.

The explanation of this difference is, I believe, to be found in the structure of the mouth. That of the caterpillar is provided with a pair of strong jaws, fitted to eat leaves; and the digestive organs are adapted for this kind of food. On the contrary, the mouth of the butterfly is suctorial; it has a long proboscis, beautifully adapted to suck the nectar from flowers, but which would be quite useless, and indeed only an embarrassment to the larva.

* For differences in larvæ consequent on variation in the external conditions, see *ante*, p. 31.

The digestive organs also are adapted for the assimilation, not of leaves, but of honey. Now it is evident that if the mouth-parts of the larva were slowly metamorphosed into those of the perfect insect, through a number of small changes, the insect would in the meantime be unable to feed, and liable to perish of starvation in the midst of plenty. On the contrary, in the Orthoptera, and as a general rule, among those insects in which the changes are gradual, the mouth of the so-called larva resembles that of the perfect insect, and the principal difference is in the presence of wings.

Similar considerations throw much light on the nature of the chrysalis or pupa state—that remarkable period of death-like quiescence which is one of the most striking characteristics of insect metamorphosis. The comparative quiescence of the pupa is mainly owing to the rapidity of the changes going on in it. In the chrysalis of a butterfly, for instance, not only (as has been already mentioned) are the mouth and digestive organs undergoing change, but the same is the case with the muscles. The powerful ones which move the wings are in process of formation; and even if they were in a condition favourable to motion, still the nervous system, by which the movements are set on foot and regulated, is also in a state of such rapid change that it could scarcely act.

It must not be forgotten that all insects, indeed all articulate animals, are inactive for a longer or shorter space of time after each moult.

The slighter the change the shorter the period of inaction. Thus, after the ordinary moult of a caterpillar, the insect only requires rest until the new skin is hardened. When, however, the change is great and gradual, the period of inaction is correspondingly prolonged. The inactivity of the pupa is therefore not a new condition peculiar to this stage, but a prolongation of the inaction which accompanies every change of skin. Most pupæ indeed have some slight powers of motion; those which assume the chrysalis state in wood or under ground usually come to the surface when about to assume the perfect state, and the aquatic pupæ of certain Diptera, swim about with much activity. Among the Neuroptera certain families have pupæ as quiescent as those of the Lepidoptera; others, as, for instance, Raphidia, are quiescent at first, but at length acquire sufficient strength to walk, though enclosed within the pupa skin, a power dependent partly on the fact that this skin is very thin. Others again, as, for instance, dragon-flies, are quiescent on assuming the pupa state, only in the same manner and for a similar time as at other changes of skin.

JOHN LUBBOCK

(*To be continued.*)

## NOTES FROM THE "CHALLENGER"

### III.

### THE MILLER-CASELLA THERMOMETER

AT 8 A.M., on March 26, we sounded, lat. 19° 41′ N. long. 65° 7′ W., in 3,875 fathoms. The sounding was perfectly satisfactory, and left no doubt that the depth was estimated within a very small error. The "Hydra" sounding instrument was used weighted to 3 cwt. A slip water-bottle, and two Miller-Casella thermometers (Nos. 39 and 42) were sent down along with it as usual. The tube of the "Hydra" came up filled with a reddish clay containing a considerable quantity of carbonate of lime. The two thermometers were broken, and as the mode in which the fracture occurred is in itself curious, and has an important bearing upon the use of these instruments at extreme depths, I will briefly describe the condition of the thermometers when they came to the surface.

No. 39, a valuable instrument, with a small and constant error, which we had used for some time whenever for any reason we required extreme accuracy, was shattered to pieces (Fig. 1).

In No. 42 this instrument was externally complete, with the exception of a crack in the small unprotected bulb on the right limb of the U-tube. The inner shell of the protected bulb was broken to pieces (Fig. 2).

In both of these cases there seems little doubt that the damage occurred through the giving way of the unprotected bulb. In No. 39 the upper part of that bulb was ground into coarse powder, and the fragments packed into the lower part of the bulb and the top of the tube. The large bulb and its covering shell were also broken, but into larger pieces, disposed as if the injury had been produced by some force acting from within. The thermometer tube was broken through in three places; at one of these, close to the bend, it was shattered into very small fragments. The creosote, the mercury, and bubbles of air were irregularly scattered through the tube, and it is singular that each of the steel indices had one of the discs broken off. The whole took place no doubt instantaneously by the implosion of the small bulb, which at the same time burst the large bulb and shattered the tube.

In No. 42 a crack only occurred in the small bulb, either through some pre-existing imperfection in the glass or from the pressure. When the pressure became extreme the crack yielded a little, and the sea-water was gradually forced in, driving the contents of the thermometer before it, and taking it at a disadvantage from within, breaking the shell of the large bulb, which was unsupported on account of the belt of rarified vapour between it and its outer-shell. The pressure was now equalised within and without the instrument, and the injury went no farther. Alcohol, creosote, mercury, and sea-water were mixed up in the outer case of the large bulb, with the debris of the inner bulb, and one of the steel indices lay uninjured across the centre of it.

It now becomes an important question why the thermometer should give way at that particular point, and one still more important, how the defect is to be remedied. At first sight it is difficult to imagine why the small bulb should give way rather than the outer shell of the large one. The surface exposed to pressure is smaller, the glass is thicker, and it is somewhat better supported from within, as the tube is nearly filled with fluid under the pressure of an atmosphere. I believe the cause must be that the end of the small bulb is the last point of the instrument heated and sealed after the tube is filled with liquid, and that, consequently, the annealing is imperfect at that point. It is evidently of no use to protect the small bulb in the same way in which the large bulb is protected. The outer shell is merely a precaution to prevent the indications being vitiated by the action of pressure on the elastic bulb. Against crushing, it is no protection; rather a source of weakness, from its greatly increasing the surface. The only plan which seems to be feasible is to thicken the small bulb itself, and, if possible, to improve its temper. It is only fair to say that these thermometers were tested and guaranteed to only three tons on the square inch, and that the pressure to which they were subjected was equal to four tons.

WYVILLE THOMSON

FIG. 1

FIG. 2

## NOTES

THE Albert Gold Medal of the Society of Arts has this year been awarded to M. Chevreul, Member of the Institute of France, and Director of the Gobelins and of the Jardin des Plantes at Paris, for his valuable researches in connection with Saponification, Dyeing, Agriculture, and Natural History, which, for more than half a century, have exercised a wide influence on the industrial arts of the world.

PROF. HUMPHRY announces that the Cambridge class for Practical Histology will meet during the months of July and August at the Anatomical Museum on Tuesdays, Thursdays, and Saturdays, at 9 A.M., commencing July 1. The Class for Human Osteology will meet on Mondays, Wednesdays, and Fridays at the Anatomical Museum at 9 A.M. during July and August, commencing July 2. The Professor of Zoology and Comparative Anatomy (Mr. Newton) announces that a class for practical work will be carried on in July and August by the Demonstrator in Comparative Anatomy, commencing July 2. The fee for the course will be one guinea.

THE following gentlemen have been recommended by the French Academy of Sciences to the Minister of Public Instruction for the four vacant posts in the Bureau des Longitudes:—M. Serret, M. Mouchez, M. Perrier, and M. Janssen.

THE Council of the Society of Arts having been informed that Her Majesty's Commissioners do not intend to publish reports on the different departments of the exhibition of the present year, have decided to undertake that duty, and for this purpose have engaged the services of gentlemen specially skilled in the subjects of the several sections, to prepare such reports for publication in the Society's *Journal*. A report on Ancient Objects, by Mr. C. Drury Fortnum, F.S.A., and another on Surgical Instruments and Appliances, by Mr. R. Brudenell Carter, F.R.C.S., appear in the *Journal* for May 30.

AT a meeting of the Council of the Leeds Naturalists' Field Club and Scientific Association, three of its members—Mr. Wm. Todd (vice-president), Mr. W. D. Roebuck (secretary), and Mr. John W. Taylor—were appointed a sub-committee to consider the best manner of collecting information for a series of catalogues of the natural productions of the district. The sub-committee having taken into consideration all the facts bearing upon the subject in hand, are of opinion that the following procedure should be adopted:—1. That in view of the approaching meeting in Bradford, in August next, of the British Association for the Advancement of Science, it is advisable that there should be produced by this society, and under its auspices, a brief account of the present state of our knowledge of the fauna, flora, and geological and topographical features of the district. 2. That for present use the most convenient district to illustrate would