after traversing only a part of that ocean. On the other hand, others are formed over the Atlantic, and especially in the vicinity of Newfoundland, where there is the mingling of hot and cold water, and where, as shown by both air- and sea-isotherms, there is a very great difference of temperature in a very small area. There are numerous instances both of the formation of storms and also of their sudden breaking up. It is also seen how at one time a storm will divide into two parts, and each will follow its independent course, while at another time two well-developed storms will merge and become one. The charts show how, as one of these travelling disturbances is approaching the British Islands, the weather becomes unsettled, and how, as the outer edge of the front segment strikes our coasts, the wind backs to the southward, and in a short time rain begins to fall and the wind freshens. If the disturbance passes over the British Islands, the changes are generally both important and rapid, whilst, if the storm area merely skirts our western coasts, as is the more common experience, the changes are less marked, and influence in the main only our western and northern coasts. The first issue of these charts deals only with the autumn, but they show very different conditions of weather at the early part of this season from those at its close, the whole system of weather being more disturbed as the season advances. There is, however, throughout the period a permanent area of high barometric pressure situated in mid-Atlantic, on the northern side of which the travelling disturbances move. This area of high barometer oscillates from day to day within fairly well-defined limits, and is very seldom altogether broken up; and doubtless a close study of the behaviour of this high-pressure area will tend to materially advance our knowledge of the now almost hopelessly puzzling weather changes with which in weather-forecasting we have to combat.

Among other points of interest exhibited by the charts may be mentioned the graphic manner in which the earlier charts show the meeting of the north-east and south-east trade-winds and the seasonal march of the limits of these winds with the sun. They also show that at the end of the summer the temperature of the air is warmer than the sea to the extent of 2° or 3°, while, as winter is approached, the sea is slightly the warmer. In September there is a good instance of the formation of a West Indian hurricane which eventually crosses the Atlantic and passes to the north of Scotland, and the chart of November 1 shows the vast extent of some of these Atlantic storms, one gale blowing over the whole ocean from the coast of America to that of Europe.

It is scarcely possible to over-estimate the high value of this series of charts. The most practical outcome of their publication, it is hoped, will be an improvement of our weather forecasts and storm warnings and a general extension of our knowledge of the laws which regulate the weather changes in our own islands; whilst from a nautical point of view they are of the utmost value to the seaman in enabling him to follow in detail the many changes he experiences, and they may assist him at times in making a better passage.

GILDED CHRYSALIDES[1]

PREVIOUS WORK.—Mr. T. W. Wood in 1867 published the observation that certain pupæ (*Pieris brassicæ, P. rapæ*, &c.) resemble in colour the surface on which they are found. Although this was disputed by some naturalists, it was confirmed by Mr. A. G. Butler and Prof. Meldola. In 1874 Mrs. M. E. Barber published some very striking observations on the colours of the pupa of *Papilio nireus* (South Africa), confirmation being afterwards afforded by Mr. Trimen, from the case of *Papilio demoleus*. Dr. Fritz Müller, however, shows that *Papilio polydamus* is not sensitive to surrounding colours. The observations were explained by supposing the moist skin of the freshly-formed pupa to be "photographically sensitive" to the colour of surrounding surfaces; but Prof. Meldola pointed out that there can be no real analogy with photography. Furthermore, many pupæ are formed at night, when the surrounding surfaces are dark. The present investigation was undertaken with the belief that the influence would be found to work upon the larva as it rests upon some coloured surface before pupation.

I. *Experiments upon Vanessa Io.*—This pupa appears in two varieties, being commonly dark gray and much more rarely yellowish-green. Six larvæ placed in a glass cylinder covered with green tissue-paper, produced six green pupæ; one of these, transferred to a black surface while still moist and fresh, became a green pupa precisely like the others.

II. *Experiments upon Vanessa urticæ.*—The pupæ have no green form, but appear in many shades of dark gray, the lighter ones having golden spots on them, while the extreme forms are almost covered with the golden appearance. These latter are very rarely seen in nature, except when the pupa is diseased. Over 700 pupæ were obtained in the following experiments:—

1. *Effects of Colours.*—*Green* and *orange* surroundings caused no effect on the pupal colours; *black* produced, as a rule, dark pupæ; *white* produced light pupæ, many of them being brilliantly golden. This last result suggested the use of *gilt* surroundings, which were found to be more efficient than white, and produced pupæ with a colour which even more resembled gold.

2. *Mutual Proximity.*—The larvæ being dark, it was found that when many of them became pupæ on a limited (white or gilt) area, the pupæ were darker than when they had been more isolated. The colours of each were in fact affected by that part of the surroundings made up by the black skins of its neighbours.

3. *Illumination.*—Black surroundings produced rather stronger effects in darkness than in light, but the pupæ were dark in both cases.

4. *Time of Susceptibility.*—The mature larvæ, after ceasing to feed, wander (stage i.) until they find a surface on which to pupate; they then rest upon it (stage ii.), and finally hang, head downwards, suspended by their last pair of claspers (stage iii.), in which position pupation takes place. Stage i. is variable in length, stage ii. may be estimated at 15 hours (but it is also variable), while stage iii. is fairly constant, and lasts about 18 hours; while the whole period is commonly about 36 hours in length. The larvæ are probably affected by surrounding colours for about 20 hours before the last 12 hours of the whole period, and in this time the pupal colours are determined. These facts were discovered by a very large number of experiments, in which larvæ were placed in surroundings of one colour, and then after a variable time were transferred to another colour producing an opposite effect. It was thus found that stage ii. is more sensitive than stage iii., although there is some susceptibility during the latter stage.

5. *The Part of the Larvæ which is Sensitive to Colour.*

(*a*) *The Ocelli.*—The most obvious suggestion was that the larval eyes (or ocelli, six on each side of the head) saw the colours, and, being influenced, transmitted an impulse to the nervous centres which regulate the formation of the pupal colours. When, however, these organs were covered with black varnish, the pupæ resembled surrounding surfaces to the same extent as when they were produced from normal larvæ.

(*β*) *The Complex Branching Spines.*—It seemed possible that these structures might contain some organ which was influenced by the colour, but after cutting them off the larvæ remained normally sensitive.

[1] Abstract of Lecture delivered by Mr. Edward B. Poulton at the Royal Institution, on Friday, February 11.

(γ) *The General Surface of the Skin.*—This was tested by *conflicting colour experiments.* It had been previously shown that the larvæ were sensitive during stage iii., and therefore they were covered in this stage with compartmented tubes, so constructed that the head and anterior part of the body hung in the lower chamber of one colour, while the posterior part of the body was in the upper chamber in another colour. In another method the larvæ were hung upon a vertical surface, while the head and front part of the body passed through a hole in a shelf, the vertical surface above the shelf, and the upper side of the shelf itself being one colour, while the vertical surface below the shelf and the lower side of the shelf were of the colour tending to produce the most opposite effects. The result of all these experiments was to show that the colour influence does act on some element of the larval skin, and that the larger the area of skin exposed to any one colour the more does the pupa follow its influence. Parti-coloured pupæ were not obtained, thus perhaps pointing towards the action of the nervous system rather than towards the direct action of light on or through the skin itself.

6. *The Nature of the Effects Produced.*—The colouring-matter of the dark pupæ is contained in a thin superficial layer of the cuticle; below this is a thicker layer divided into exceedingly delicate lamellæ, between which fluids are present, and the latter form the thin plates which, by causing interference of light, produce the brilliant metallic appearance. The thinner upper layer, being dark, acts as a screen in the dark pupæ. Precisely the same metallic appearances are caused by the films of air between the thin plates of glass which are formed on the surface of bottles long exposed to earth and moisture. Both have the same spectroscopic characters and the same transmitted colours (complementary to those seen by reflection). The brilliancy of the cuticle can be preserved in spirit for any length of time; it disappears on drying, but can be renewed on wetting (this had been previously known), and the colours are seen to change during the process of drying, and when the cuticle is pressed, for the films are thus made thinner. The same lamellated layer exists in non-metallic pupæ of other species, and is used as a reflector for transparent colouring-matter contained in its outer lamellæ. Thus the structure which rendered possible the brilliant effects due to interference probably existed long before these special effects were obtained, and was used for a different purpose.

7. *The Biological Value of the Gilded Appearance.*—It is probable that the gilded pupæ of Vanessidæ resemble glittering minerals such as mica (which is very common in many places); their shape is very angular, and like that of minerals: conversely the gray pupæ resemble gray and weathered rock-surfaces, and the two conditions of rock would themselves act as a stimulus for the production of pupæ of corresponding colour. The power was probably gained in some dry hot country, where mineral surfaces do not weather quickly. Once formed, it may be used for other purposes, and in certain species is probably a warning to the enemies that the insect is inedible. It is interesting to note how the Vanessidæ, primarily coloured so as to resemble mineral surroundings, are modified for pupation on plants. Thus *Vanessa Io* has a green form which is produced among leaves; *V. atalanta* has no green form, and spins together the leaves for concealment, but both these species commonly pupate freely exposed on mineral surfaces; *V. urticæ* has neither the green form nor the habit of concealment, and it has a strong disinclination to pupate on its food-plant, as many observations concurred in proving.

III. *Experiments upon Vanessa atalanta.*—This species was also made brilliantly golden or dark-coloured by the use of appropriate surroundings in the larval condition.

IV. *Experiments upon Papilio machaon.*—This species, like *P. polydamus* (Fritz Müller), has no power of being influenced by surrounding colours. A brown pupa was obtained on the food-plant, and many green ones upon brown twigs, &c. It is possible that the amount of shade may determine the formation of the dark pupa irrespective of colour, or that less healthy and smaller larvæ may produce the brown form, just as diseased Vanessa larvæ produce gilded pupæ.

V. *Experiments upon Pieris brassicæ and P. rapæ.*

1. *Effects of Colours.*—*Black* produced dark pupæ, and the greater the illumination the darker the pupæ (*P. rapæ*), this result being the reverse of that obtained with *V. urticæ*; *white* produced light pupæ, and the greater the illumination the lighter the pupæ (*P. rapæ*); *dark red* (*P. brassicæ*) produced dark pupæ; *deep orange*, in both species, produced very light pupæ of a green colour; *pale yellow* and *yellowish green* produced rather darker pupæ than the orange; *bluish-green* produced much darker pupæ; while *dark blue* produced still darker pupæ (*P. rapæ* only). Hence there is a remarkable and sudden fall, followed by a slow and gradual rise in the amount of pigment formed as the light from various parts of the spectrum from red to blue predominates in the reflected rays which fall on the larval surface. But their effects on the formation of superficially placed dark pigment are accompanied by changes affecting the formation of greens and yellows, &c., in the deeper sub-cuticular tissues. Hence the results of any given stimulus are exceedingly complicated.

2. *Other Experiments.*—It was shown by the method described above that the ocelli are not sensitive in this species, and by similar transference experiments it was proved that the influence acts on the larva and not on the pupa itself.

VI. *Experiments upon Ephyra pendularia.*—In this genus of moths the exposed pupæ are often green and brown in different individuals, but these colours follow the corresponding tints of the larvæ, and therefore cannot be influenced unless the latter themselves were changed, and such susceptibility in the larval state has not been proved for this genus. This is the only known instance of a constant relation between the larval and pupal colours.

VII. *Experiments upon the Cocoon of Saturnia carpini.*—It was found that the larvæ spin dark cocoons in black surroundings, but white ones in lighter surroundings.

NOTES

The principal officers for the Manchester meeting of the British Association, to begin on August 31, under the presidency of Sir Henry Roscoe, have now been selected. The following will be the Presidents of the various Sections:—Section A, Mathematics and Physics, Sir Robert S. Ball, Astronomer Royal for Ireland; B, Chemistry, Dr. Edward Schunck, F.R.S.; C, Geology, Dr. Henry Woodward, F.R.S.; D, Biology, Prof. A. Newton, F.R.S.; E, Geography, General Sir Charles Warren, R.E., G.C.M.G.; F, Economic Science, Dr. Robert Giffen; G, Mechanical Science, Prof. Osborne Reynolds, F.R.S. For Section H, Anthropology, a President has not yet been chosen. One of the public lectures will be given by Prof. H. B. Dixon, who has taken as his subject "The Rate of Explosions in Gases." The lecture to the working classes will be given by Prof. George Forbes. It is expected that, socially, the Manchester meeting will be one of the most brilliant ever held. A very large sum has already been subscribed, and liberal arrangements are being made for excursions and other entertainments.

The trustees of the fund established by Mrs. Elizabeth Thompson, of Stamford, Connecticut, "for the advancement and prosecution of scientific research in its broadest