cules of hydrogen when this body is compressed to a density comparable with the density of liquids.*

"The Experimental Proof that the Colours of certain Lepidopterous Larvæ are largely due to modified Plant Pigments derived from Food." By Edward B. Poulton, M.A., F.R.S.

Received May 12,—Read June 8, 1893.

[Plates 3 and 4.]

In a paper printed in the 'Proceedings of the Royal Society' for 1885 (pp. 269—315), I brought forward many reasons for regarding certain elements of the colouring of Lepidopterous larvæ as modified chlorophyll derived from the food plant. For this altered pigment the name metachlorophyll was suggested (*loc. cit.*, p. 270). Many other observations, subsequently made, supported the same conclusion; but it was not until the summer of last year (1892) that I was able successfully to carry out the critical experiment, viz., selecting a species of larva which normally eats green leaves, to feed it from the egg upon parts of the plant from which all colouring matter is absent.

This experiment was carried out in the following manner:—

A captured female of *Tryphæna pronuba* laid many hundreds of eggs in a chip box. The first larvæ began to appear September 7, 1893. On this and the subsequent dates, the larvæ intended for the purposes of these experiments were arranged in three sets, fed respectively upon—(1) the yellow etiolated leaves from the central part of the heart of the cabbage, (2) the white mid-ribs of such leaves from which the yellow blade was carefully removed with scissors, (3) the deep green external leaves of the same plant.

In all other essential respects the conditions of the three sets were the same. All were kept in the dark to prevent the change of the etiolin into chlorophyll. They were only exposed to light during the times necessary for comparison and feeding, and these are indicated below. A few were kept in glass cylinders standing on plates, the majority being confined in white earthenware pots covered at first with white muslin, but subsequently with glass sheets. Eventually all were kept in pots.

It is clear that the only essential difference between the conditions of the sets was the fact that the food of the first contained etiolin but

* Lord Kelvin states that in "any ordinary liquid" the mean distance between the centres of contiguous molecules is, with a "very high degree of probability," less than 0·0000002 and greater than 0·000000001 of a centimetre. See 'Roy. Institution Proc.,' vol. 10, p. 185.

no chlorophyll, while the food of the second contained only a little etiolin, and that so situated (around the fibrovascular bundles and buried deeply in the substance of the mid-ribs) that the larvæ could not make use of it, while the food of the third contained abundant chlorophyll.

It is evident that any constant difference between the larval colours in the three sets followed from these differences in the food supplied them; and, unless there are reasons for believing that the differences were due to pathological change, and thus an *indirect* result of the food, we must hold that they are a *direct* result, and that important elements of the larval colouring are dependent on the existence of some modification of pigments derived from their food.

The course of the experiment will now be described in a tabular form.

Dates.	(1) Etiolated leaves.	(2) White mid-ribs.	(3) Green leaves.
Sept. 7	18 larvæ, the first to hatch, introduced.		
Sept. 8	45 larvæ added.	About 50 larvæ introduced into 2 pots.	75 eggs, from which the larvæ were hatching, introduced.
Sept. 22	Re-fed; 40 placed in a cylinder and about 18 in a pot.	Re-fed; about 20 alive in each pot.	Re-fed; about 30 larvæ counted.
Sept. 27	Length about 8·5 mm. Some of these larvæ were distinctly, although rather faintly, green. 20 removed from cylinder into new pot.	All white, with no greenish tinge. 10 removed and placed in a bottle, and 10 in a new pot.	Re-fed; 28 or 29 counted.
Oct. 4	The longest larva 15·75 mm. long when extended in walking. Many changing skin. The black subdorsal semilunar marks distinct in many of the largest. Most were pale, but distinctly green, and all apparently with *some* green shade; very different from the pale yellow colour of the etiolated leaves. The larvæ remaining in cylinder were now placed in a pot.	Again re-arranged: 9 placed in one pot, 9 in another, and 11 of the smallest in a third.	28 counted; 1 killed accidentally; 13 placed in one pot, and 14 in another.
Oct. 10	All very carefully compared. 27 in 4th stage, very uniformly about 23·0 mm. long, when fairly extended at rest; 5 *pale distinct green; 12 dark greenish*, varying according to the amount of dark superficial pigment, and transitional into	24 alive. Again re-arranged in 4 groups, placed in separate pots, containing respectively the 5 largest, the 9 next in size, the 5 next in size, and the 5 smallest. The largest were in 2nd stage. All quite white, being quite as large as those fed	These larvæ were frequently compared together and with those of experiment (1). There was no essential difference, except that these grew rather more slowly. At this time they were similarly

Dates.	(1) Etiolated leaves.	(2) White mid-ribs.	(3) Green leaves.
	the *brown* larvæ (10) in which the green colour is absent. The palest green larva, a similar larva with more superficial pigment, a typical dark greenish, and a typical brown larva were selected for painting at this date, together with a *very* deep bluish-green larva, which changed its 3rd skin just before being painted (see Pl. 3, fig. 1). The shade of green was far deeper than in any other individual. 11 larvæ in 3rd stage, the largest being 18—19 mm. long when extended. 7 *pale green*, 1 *pale brown*, 3 *deep brown*. 23 larvæ changing 3rd skin. 13 *pale green*, 5 *darkish green*, including the deep bluish-green one represented in fig. 1, Pl. 3 (4 of these changed their skins during the comparison), 6 *brown* (2 being greenish and transitional).	upon etiolin (1) on Sept. 27, when they began to become green.	green and brown of various shades, darkening, as they entered the last stage, into brown.
Oct. 11		3 of the largest were figured (see Pl. 3, fig. 2). They were in the 2nd stage.	
Oct. 19	The larvæ had grown rapidly, and a few had entered the last stage, while several were changing the last skin. As they matured they became darker, and all	5 largest were all about 11 mm. long when extended; 3 were changing 2nd skin, 2 large in 2nd stage. Same white appearance with faint greyish shade, due to	

Dates.	(1) Etiolated leaves.	(2) White mid-ribs.	(3) Green leaves.
	eventually turned brown, mostly of a dark shade.	superficial true pigment. Of the 9 next in size 3 were dead, and the 5 smallest were all dead or dying.	
Oct. 26	Nearly all in last stage, and brown of various shades, occasionally faintly greenish.	The 2 largest were 12·0 and 13·5 mm. long respectively when extended. Of the 6 next in size 2 were dead, and of the remaining 5, 2 were dying.	
Oct. 29		Of the 5 largest, 4 were dead by this date or in the course of the next day or two. The remaining larva was placed (Oct. 29) on etiolated leaves.	
Nov. 2	Mostly mature, and various shades of brown. When carefully compared with the larvæ fed on green leaves (3) no difference in colour could be seen, except such as was due to the colour of the food in the digestive tract. This was also true of earlier stages.	The larva on etiolin remained as white as before. Of the next in size 3 were alive, 1 of which had grown very much, and seemed to be near the end of the 3rd stage. It was very white and maggot-like. The smallest was placed on etiolin. Of the 5 remaining larvæ 2 were alive. 1 was very small, and apparently in the 1st stage, the other probably at end of 2nd stage. Both were placed on etiolin.	Carefully compared. 23 alive in 4 pots. 20 in last stage, and all various shades of brown except 2, which were slightly greenish and distinctly greenish respectively, the latter having only just changed skin. 1 was in 4th stage; 2 were changing last skin (1 green and 1 light brown).
Nov. 9		Of the only 2 larvæ now eating the white	The 3 last mentioned larvæ and the

Dates.	(1) Etiolated leaves.	(2) White mid-ribs.	(3) Green leaves.
		mid-ribs the larger one had grown considerably. The 4 on etiolin were still alive, and seemed to have become yellower, but not more so than was to be expected from the food in the digestive tract.	distinctly greenish one in last stage were kept together and compared at this date. 1 was dead; 1 was small in last stage (dark brown); 2 were large in last stage (1 light brown and 1 somewhat greenish-brown).
Nov. 16		Of the 4 on etiolin 2 were dead (including the larva first placed on it), the others still faintly yellowish.	
Nov. 20		The largest larva was now 21·5 mm. long when extended at rest; the other was dead. Only 1 larva alive on etiolin, and that died Nov. 21.	
Nov. 28		The remaining larva had grown greatly, and was advanced in the 4th stage. A great development of superficial pigment had appeared suddenly between this date and Nov. 20, especially marked upon the brown head, prothoracic plate, and supra-anal plate, and in the dark subdorsal semilunar marks; minute black points were also abundantly scattered over the whitish general surface. The white sub-	

Dates.	(1) Etiolated leaves.	(2) White mid-ribs.	(3) Green leaves.
		dorsal line was opaque, and evidently followed from some structural cause (probably pigmentary) distinct from that to which the pale whitish general surface was due. This was perhaps the case with the white spiracular line also. When at rest the length varied from 20·0 to 22·0 mm. according as the larva was moderately contracted or moderately extended. On December 2 the larva was painted (in the 4th stage) in two attitudes (see Pl. 4, fig. 1).	
Dec. 16		The larva was resting before changing the last skin; it was 29·0 mm. long when extended at rest.	
Dec. 18		The last skin had now been shed, and the larva was *much* darker, although the ground colour seen between the dark pigment spots was as pale as before. Hence the effect was greyish. On the evening of the 17th, before ecdysis, the increase of superficial pigment was observed, especially in the dorsal, subdorsal, and supra-spiracular regions.	
Dec. 29		The larva was painted when much grown in last stage (Pl. 4, figs. 2 and 3).	

Dates.	(1) Etiolated leaves.	(2) White mid-ribs.	(3) Green leaves.
Jan. 1, 1893		At this date the larva was offered etiolated leaves, but did not appear to eat at all, and seemed to be hybernating. The appearance did not alter. On Jan. 14th it was killed accidentally.	

Before discussing the conclusions, it will be best to consider the possible effect of certain conditions incidental to the experiments.

Darkness.—The almost continuous darkness probably affected the colours of the larvæ in (1) and (3), as they became mature. The adult larvæ of *T. pronuba* are sometimes bright green; and some of the larvæ, hatched from the batch of eggs which supplied these experiments, reared by Miss L. J. Gould in the light and with green surroundings, remained a distinct, although dark, green until maturity, quite unlike any of those referred to above.

Although it is thus probable that the larvæ are sensitive, like so many others, to the colour and degree of illumination of their surroundings, the results of these experiments are not affected in any essential respect; for there was abundant opportunity for comparison *before* the changes referred to had taken place (*e.g.*, October 10), and when the majority of the larvæ in (1) and (3) were green (see Plate 3, fig. 1). Furthermore it is also evident that the comparison was equally valid *after* the change had taken place, inasmuch as the brown ground colour, no less than the green, is shown to be due to a modified plant pigment.

Nutritive Value of Pigmentless Food.—The extremely slow growth of the larvæ fed upon the white mid-ribs, and the death of all except one of them in an early stage, may be looked upon as an argument that they were in a pathological condition, one result being the inability to form a certain kind of pigment. Such an interpretation would, of course, upset the conclusions I have arrived at.

On the other hand, it may be urged that the single larva in (2) which survived until it was advanced in the last stage was certainly not pathological, and yet was unable to form the pigments in question. Although it grew very slowly in early youth, it began to be conspicuous by its size on November 2, and from this date it grew rapidly and fed largely (see Plate 4, figs. 1 and 2); judged by all standards, it was perfectly healthy. Furthermore, everyone who breeds larvæ knows that they are subject to diseases of various kinds, and yet, so far as I am aware, the complete inability to form certain classes of pigment has not been recognised as a symptom. Moreover, the larvæ fed on the thick succulent etiolated leaves (1) grew far more rapidly then those fed on green leaves (3). This species hybernates in the larval state, and, as is usually the case in such species, the rate of growth is extremely irregular. Many of the larvæ reared by Miss Gould, and single larvæ fed upon green leaves by me, lagged far behind the others and yet remained healthy.

I believe that the retarding effect of the mid-ribs was not due to the absence of plant pigments, but to the rapid drying and oxidation of the cut surfaces (left by the removal of the rest of the leaf) and the inability of the young larvæ to get sufficient food from other parts,

where the tough cuticle could not be easily penetrated by their small weak mandibles. The larger larvæ do not experience the same difficulty.

It will be well, however, to repeat the experiment with other larvæ, some of which may be expected to have greater powers of endurance. I would suggest *Mamestra brassicæ* and *Phlogophora meticulosa* as suitable for the purpose. Freshly cut mid-ribs might be offered every day or perhaps twice a day.

Conclusions from the Experiments.—Assuming that the results obtained in Experiment (2) are not pathological, and I believe that this assumption is justified, it follows that etiolin (1), no less than chlorophyll (3), can be transformed into a larval colouring matter, which may be either green or brown, and is so disposed as to form a ground colour.

The fact that *brown* pigments may be thus formed is new. In my previous paper ('Roy. Soc. Proc.,' 1885, pp. 269 *et seq.*) I gave reasons for the conclusion that the green pigments are derived from plants, but argued that brown pigments are proper to the larva. This still remains true in many cases. Thus the green larvæ of *Amphidasis betularia*, investigated in 1892, are coloured by derived pigments contained in the superficial fat, while the brown larvæ are coloured by true pigment contained in the epidermic cells (' Trans. Ent. Soc. Lond.,' 1892, pp. 357—359), so that the green fat which lies beneath is concealed. The intensely opaque and dark larvæ of many other Geometræ are probably similarly coloured by true pigments in the cuticle or epidermis. But the brown ground colour of many Noctua larvæ will probably be found to be due, like that of *T. pronuba*, to modified plant pigments.

A comparison of the larvæ fed on pigmentless food (Plate 3, fig. 2, Plate 4, figs. 1—3) with those fed upon etiolated leaves (Plate 3, fig. 1) and the similar larvæ fed upon green leaves, proves that both green and brown ground colours are modified plant pigments. When the larvæ fed on etiolin were being compared on October 10, one of them became irritated and expelled a drop of fluid from its mouth. This fluid was of a faintly *bluish-green* colour. This observation suggests that the change of etiolin into a soluble green pigment takes place in the digestive tract. Chlorophyll similarly becomes soluble and forms a green solution (turning brown on exposure) in the digestive tract of larvæ. It is possible that the brown ground colour of the larvæ is also a result of oxidation: at any rate, it is a change in the direction of greater stability; for I have shown that the colours of certain brown larvæ, evidently coloured like those of *T. pronuba*, are far more persistent after preservation than those of the green varieties of the same species ('Roy. Soc. Proc.,' 1885, pp. 275, 276).

Although the brown ground colour, probably situated in this

species in the epidermic cells, is thus derived, there is an abundant deposit of true pigment in the form of spots and patches in the superficial cuticle. This was as distinct in the larvæ of (2) as in those fed upon etiolin or chlorophyll; but, the ground colour of the former being white instead of green or brown, it produced a greyish effect (Plate 4, figs. 1—3). The opaque, white stripes in the sub-dorsal and spiracular regions are also probably due to true pigment situated in this case in the epidermic cells, and are equally conspicuous in the larvæ fed on pigmentless food (Plate 4, fig. 2).

In certain parts of the body the cuticle is of relatively greater thickness—the head, prothoracic dorsal plate, supra-anal plate, true legs, and parts of the claspers. In these situations, therefore, the combination of a deeply-placed ground colour composed of derived pigments with a superficially placed true pigment would not necessarily produce the same effect as in the other parts of the body where the cuticle is much thinner; for the derived pigments would tend to be hidden. In these parts, therefore, *both ground colour and markings are cuticular, while both are composed of true pigment* of such a tint as to harmonise with the effect produced by the combination of two distinct elements in other parts of the body. Hence these parts remained normal in the larvæ of Experiment (2), resembling the brown larvæ of the other experiments, and serving to show what the colour of the rest of the body would have been if the plant pigments had been present in the food (Plate 4, fig. 3).*

Some indication was afforded in the course of these experiments that the power of converting the plant-pigments into metachlorophyll may be lost in larvæ which have been fed from the egg for a considerable time upon pigmentless food. Thus the larvæ of Experiment (2) remained pale when fed upon leaves which caused those of Experiment (1) to become brown or green. At the same time it must be remembered that these particular larvæ were certainly unhealthy, and died soon after the change of food. I hope to repeat this experiment upon healthy larvæ. I have already shown that many larvæ which are normally found upon a variety of food plants will starve rather than eat certain of them when they have been fed upon the others from the egg ('Ent. Soc. Lond. Trans.,' 1887, pp. 312—314). It is possible that a somewhat analogous "gastric education" may take place as regards the digestive action upon plant pigments. But confirmatory experiments, specially directed to test the conclusion, are much wanted.

* [This argument appears to be valid in the case of the older larvæ of this species and probably many others. There are, however, many instances in which the derived pigments are distinctly visible through an extremely thick cuticle (*e.g.*, in the head of larvæ of the genus *Smerinthus*). The distribution of the derived pigments has not been investigated in this case.—October 15, 1893.]

It is of great interest that the etiolin should be as effective as chlorophyll in the production of larval colours. It is, however, probable that the difference between etiolin and chlorophyll is, chemically, extremely small, while both appear to undergo similar changes in the larval digestive tract, yielding a substance which becomes dark coloured on exposure to air, probably by oxidation. Thus of the two heaps of fæces represented in Plate 3, fig. 1, that to the left had been exposed to the air for some hours, and was dark brown, while that to the right was fresh and of a pale-yellow tint. A cut midrib darkens on exposure quite independently of the plant pigments as may be seen in the same figure; but the tint is different, and the depth of shade far less than in the fæces containing abundant etiolin. The fæces of the larvæ fed on pigmentless food similarly darkened far less rapidly and to a much less extent than those of the others.

Although the results of these experiments are, I believe, completely successful in establishing the conclusion they were intended to test, it must be admitted that they point to the beginning of an investigation rather than its end. We now know that certain larval colours are dependent on the existence of modified plant pigments, and this naturally leads to an enquiry into the nature and causes of the processes by which chlorophyll and etiolin are converted in the animal body into a comparatively stable green or brown substance far removed from its original position in the digestive tract, and situated so as to form an important element in the effective colouring of the individual.

Description of Plates 3 and 4.

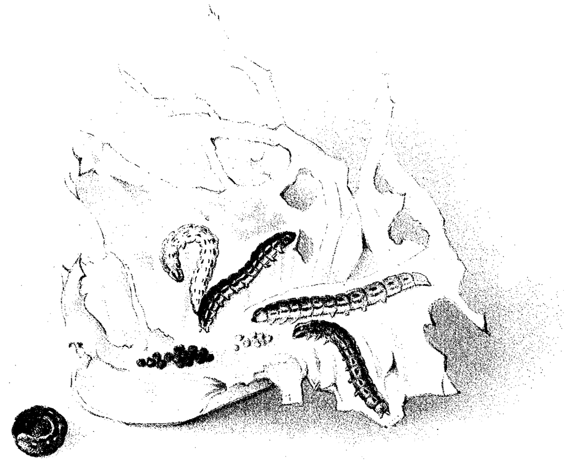
Plate 3.

Fig. 1.—A group of five larvæ of *Tryphæna pronuba* in the 4th stage, natural size. These larvæ had been fed entirely upon the etiolated leaves of cabbage. They had hatched September 7 and 8 (1893) and were painted October 10. Nearly all the shades of colour observed in the larvæ at this stage are represented in the figure, four being various shades of green, and one brown. It is clear from the figure that the larvæ can form a deep green colouring matter from etiolated leaves. There was, in fact, no difference in this respect between them and larvæ fed on green leaves.

The marked contrast in colour between the green larvæ and the leaf is some indication of the change which the etiolin has undergone in the larval body. The dark marks along the sides are due to superficially placed true pigment, which is formed independently of any coloured substance in the food plant.

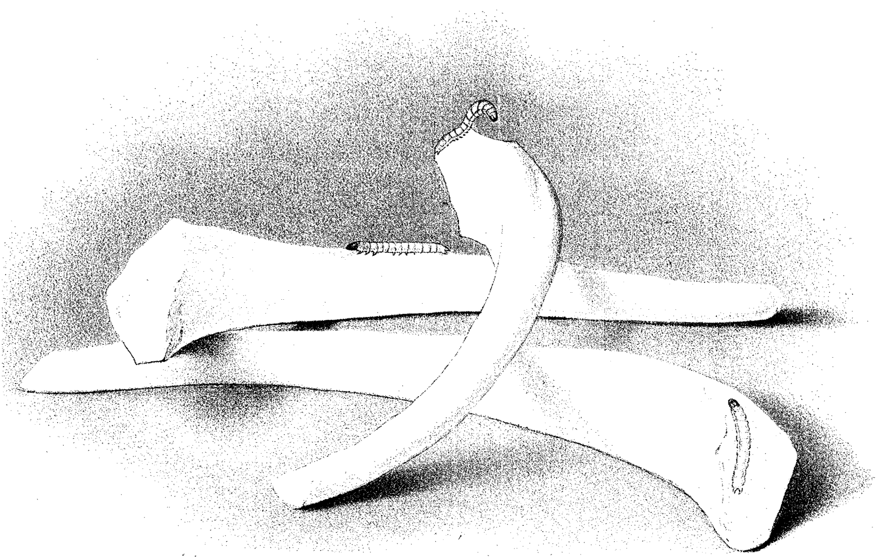
Two heaps of fæces are represented in the figure: that to the right

1.



Natural Size

2.



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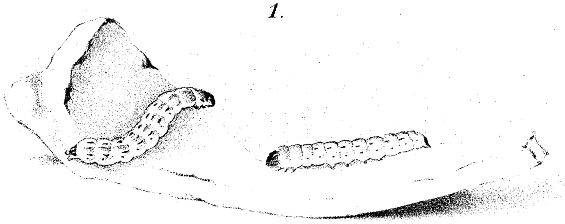
1.



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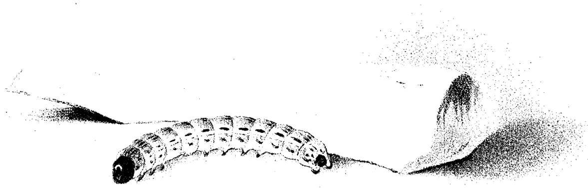

Natural Size

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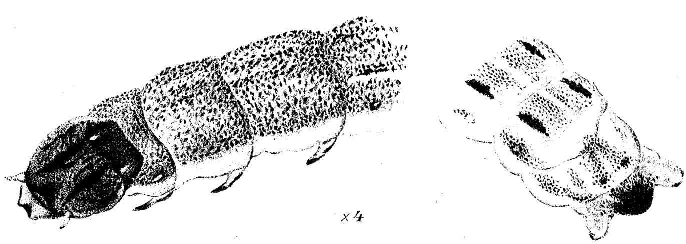

x 4

Lith. Werner & Winter, Frankfurt a/M.

fresh, and pale yellow in colour; that to the left exposed to the air for some hours, and dark brown.

Fig. 2.—A group of three larvæ, of the same species, in the 2nd stage, twice the natural size. These larvæ had been fed entirely upon the white mid-ribs of cabbage leaves. They had hatched September 8, and were painted October 11. While the larvæ represented in fig. 1 were rather larger than those fed on green leaves, these are *much* smaller. The colour is white, and maggot-like, the faint greyish appearance being due to superficial true pigment. Except upon the head, there is not a trace of either the green or the brown ground colour invariably found in the larvæ of this species under normal conditions. Furthermore, these larvæ are uniform in appearance, although the normal larvæ are extremely variable.

A comparison between figs. 1 and 2 proves that the brown or green ground colour of the species is due to some modification of etiolin (or chlorophyll in the case of normal larvæ), unless indeed the results are to be explained as pathological—an interpretation opposed to the facts represented in the figures on Plate 4.

Plate 4.

Fig. 1.—Out of about fifty larvæ which hatched September 8, and were fed on white mid-ribs, a single one began to be conspicuous by its size on November 2, and from this time it grew rapidly, and was evidently quite healthy, although all the others were dead by November 21. On December 2 it was painted (natural size) in two positions, being in the 4th stage. The ground colour remained white or cream-coloured; the grey effect being caused by superficial true pigment, which is seen to be especially marked upon the brown head, claspers, thoracic legs, prothoracic, and supra-anal plates, and upon the dark subdorsal semilunar marks.

Fig. 2.—The last skin was changed by December 18, and, on the 29th, the larva was again painted of the natural size, when advanced in the last stage. The ground colour remained the same, but an increase in the true pigment caused the larva to become a darker shade of grey. A row of supra-spiracular dark markings also made their appearance. The white subdorsal line and, perhaps, the spiracular line were evidently due to some cause of colour (probably pigmentary) distinct from that on which the pale ground colour of the general body surface depended.

Fig. 3.—At the same date the head and anterior segments were painted, × 4 diameters. In those parts where the cuticle is thickened, the head, prothoracic plate, and thoracic legs, a brown ground colour (as well as the black spots and patches) is developed from true pigment in the cuticle itself. Hence these parts remain normal when

the larvæ are fed upon leaves without chlorophyll or etiolin. But over the general surface of the body the cuticle is very thin, and only contains the black spots and patches of true pigment, while the brown or green ground colour, derived from plant pigments, is subcuticular in position. Hence in a larva fed on pigmentless parts of leaves, represented in fig. 3, this latter ground colour is replaced by a creamy tint which is due to the uncoloured tissues of the body, especially the fat, and to the contents of the digestive tract. This creamy ground colour, combined with the spots of true pigment in the cuticle, produces the general greyish appearance of these larvæ.

The posterior segments of the larva, painted at the same date, × 4 diameters, are also represented in the figure, indicating that the thickened cuticle of the supra-anal plate (which possessed a sharper outline than that represented in the figure) contains both brown ground colour and black spots of true pigment, while the general surface presents the combination of a white ground colour and dark spots, conferring a grey appearance.

Natural Size

Fig. 1.—A group of five larvæ of *Tryphœna pronuba* in the 4th stage, natural size. These larvæ had been fed entirely upon the etiolated leaves of cabbage. They had hatched September 7 and 8 (1893) and were painted October 10. Nearly all the shades of colour observed in the larvæ at this stage are represented in the figure, four being various shades of green, and one brown. It is clear from the figure that the larvæ can form a deep green colouring matter from etiolated leaves. There was, in fact, no difference in this respect between them and larvæ fed on green leaves.

The marked contrast in colour between the green larvæ and the leaf is some indication of the change which the etiolin has undergone in the larval body. The dark marks along the sides are due to superficially placed true pigment, which is formed independently of any coloured substance in the food plant.

Two heaps of fæces are represented in the figure: that to the right fresh, and pale yellow in colour; that to the left exposed to the air for some hours, and dark brown.

2.

×2

Fig. 2.—A group of three larvæ, of the same species, in the 2nd stage, twice the natural size. These larvæ had been fed entirely upon the white mid-ribs of cabbage leaves. They had hatched September 8, and were painted October 11. While the larvæ represented in fig. 1 were rather larger than those fed on green leaves, these are *much* smaller. The colour is white, and maggot-like, the faint greyish appearance being due to superficial true pigment. Except upon the head, there is not a trace of either the green or the brown ground colour invariably found in the larvæ of this species under normal conditions. Furthermore, these larvæ are uniform in appearance, although the normal larvæ are extremely variable.

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1.

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2.

Natural Size

Fig. 2.—The last skin was changed by December 18, and, on the 29th, the larva was again painted of the natural size, when advanced in the last stage. The ground colour remained the same, but an increase in the true pigment caused the larva to become a darker shade of grey. A row of supra-spiracular dark markings also made their appearance. The white subdorsal line and, perhaps, the spiracular line were evidently due to some cause of colour (probably pigmentary) distinct from that on which the pale ground colour of the general body surface depended.

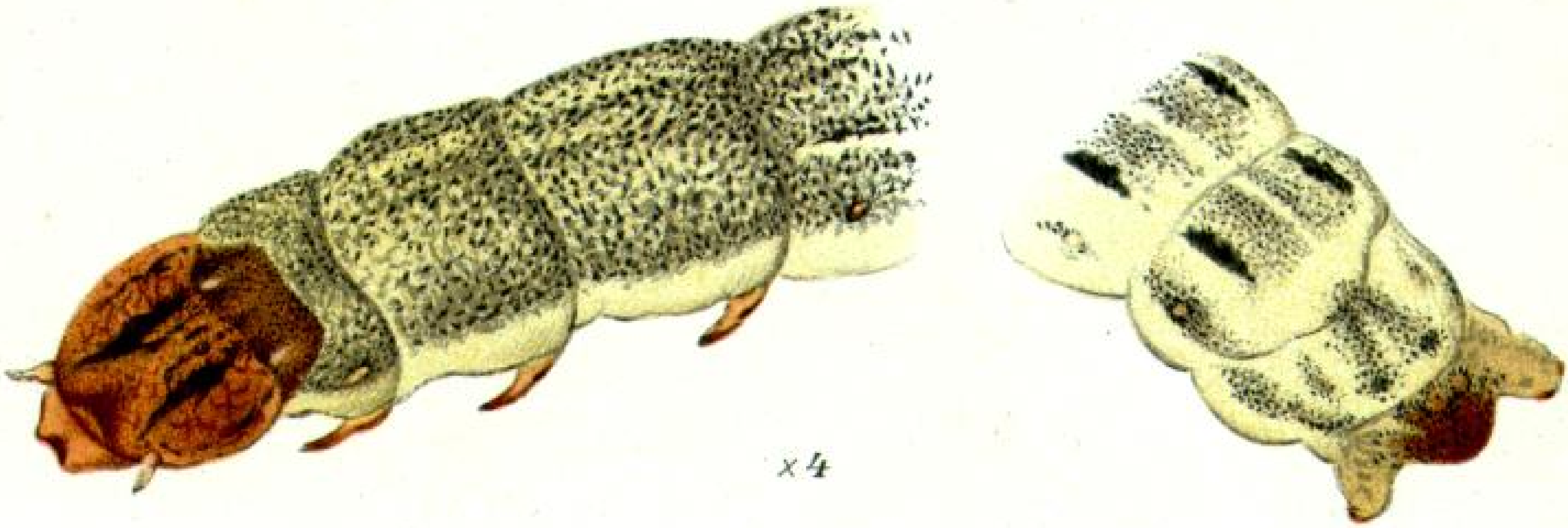

Fig. 3.—At the same date the head and anterior segments were painted, × 4 diameters. In those parts where the cuticle is thickened, the head, prothoracic plate, and thoracic legs, a brown ground colour (as well as the black spots and patches) is developed from true pigment in the cuticle itself. Hence these parts remain normal when the larvæ are fed upon leaves without chlorophyll or etiolin. But over the general surface of the body the cuticle is very thin, and only contains the black spots and patches of true pigment, while the brown or green ground colour, derived from plant pigments, is subcuticular in position. Hence in a larva fed on pigmentless parts of leaves, represented in fig. 3, this latter ground colour is replaced by a creamy tint which is due to the uncoloured tissues of the body, especially the fat, and to the contents of the digestive tract. This creamy ground colour, combined with the spots of true pigment in the cuticle, produces the general greyish appearance of these larvæ.

The posterior segments of the larva, painted at the same date, × 4 diameters, are also represented in the figure, indicating that the thickened cuticle of the supra-anal plate (which possessed a sharper outline than that represented in the figure) contains both brown ground colour and black spots of true pigment, while the general surface presents the combination of a white ground colour and dark spots, conferring a grey appearance.