



## XXXVII. On the configuration of the scales of butterflies' wings, as exhibited in the microscope

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To cite this article: Rev. Edward Craig M.A. F.R.S.E. (1839) XXXVII. On the configuration of the scales of butterflies' wings, as exhibited in the microscope , Philosophical Magazine Series 3, 15:96, 279-282, DOI: [10.1080/14786443908649876](https://doi.org/10.1080/14786443908649876)

To link to this article: <http://dx.doi.org/10.1080/14786443908649876>



Published online: 01 Jun 2009.



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continually increase the tension, and when it became infinitely great, the tension would be so too. But what is the true action of a slender wire, connecting in this way a pair of plates? A certain amount of electricity passes along it, but not the *whole quantity* that the plates could generate in a *given time*: yet we cannot but suppose that *all* that does pass comes from the *whole surface exposed*, and not from a *fractional portion* thereof. The water and zinc are ready to generate, and as it were attempting to drive a fresh quantity of electricity through the wire; and accordingly, as the quantity that actually passes becomes a greater and greater portion of what the system actually tends to put in motion, the tension becomes less and less. The tension would therefore become zero, if the whole circle wires, plates, and electrolyte could carry all that the zinc and water could generate. The limit prescribed to its diminution is the conducting power of the electrolyte, which is the worst conductor of the system.

This hypothetical condition, of a tension ranging near zero, is most nearly approximated to in a thermal pair.

Suppose now that everything remains the same, as respects wires, electrolyte, distance of plates, &c., except that the dimensions of both plates are doubled. Shall we increase the tension? No; for although the surface in action is doubled, and the absolute quantity which the system could generate is doubled, yet the quantity that passes both the primary and secondary wire is also doubled: the ratio  $\frac{b}{a}$  is therefore the

same as before. For this reason, increasing the magnitude of the plates, increases the quantity only, and not the tension.

Under all these circumstances, therefore, the tension depends on the ratio of the quantity that does pass the combination, to the quantity that the system tends to put in motion.

[To be continued.]

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XXXVII. *On the Configuration of the Scales of Butterflies' Wings, as exhibited in the Microscope.* By the Rev. EDWARD CRAIG, M.A., F.R.S.E.

[With Figures: Plate I.]

*To the Editors of the Philosophical Magazine and Journal.*  
GENTLEMEN,

**I**F the following observations are not rendered unnecessary by earlier correspondents, they are at your service for insertion in the Journal.

There are several notices in the writings of Sir David Brewster, Dr. Goring, and Mr. Pritchard on the lines upon the scales of butterflies' wings which appeared to me to leave the subject still in an unsatisfactory state. They speak of longitudinal lines, of cross striæ, and of two sets of diagonal lines besides, visible on each scale of the *P. Brassica*. It is admitted that the longitudinal and cross lines may be discovered with tolerable facility; but as to the diagonal lines, notwithstanding the distinct averments of Dr. Goring and Mr. Pritchard, a doubt still exists as to their actual existence. Dr. Goring observes that they may be seen as distinctly as the ruled lines in a copy-book, yet admits that there is "an inexplicable mystery about them." Sir David Brewster expresses with some hesitation, in opposition to such authority, his conviction that the diagonal lines are an optical illusion. He states of the whole linear appearances of the scales, that they are none of them lines, but a succession of teeth arranged in lines, and from the great number of lines forming the sides of the teeth they appear dark. Each fibre has teeth on each side of it, and the teeth of one fibre lock into the spaces between the teeth of the adjacent fibres: "the (longitudinal) lines therefore are only *apparent* lines, being composed of a succession of interlocking teeth;" and "the diagonal or oblique lines are optical illusions, from the accidental *alliguements* of the sides of the teeth in different grooves when similarly illuminated by oblique rays." Having been long familiar with these objects, and not being quite satisfied with the above statements, I submitted a great many of these scales to lengthened and intense observation. I examined them through instruments, to the use of which I am very much accustomed, and which, as all microscopic observers are aware, is of great moment for the detection of fallacious appearances: the one is a good achromatic instrument by Chevallier, the other includes a very good Wollaston's doublet, a single garnet lens by Adie of the  $\frac{1}{60}$  of an inch focus, and another by Blaikie of the  $\frac{1}{30}$ . It becomes me, in stating that I have arrived at a different result from these accurate observers, to speak with the greatest diffidence. I shall be thankful if anything stated by me shall serve only as a hint for their further consideration.

The distinct impression upon my mind, after a long series of observations, is that each scale is a film, regularly ribbed or divided by longitudinal fibres which are thicker than the rest of the film, like some corded muslins; and that each thinner portion of the film between the ribs is crossed in a slightly curved direction by still finer fibres, which become

closer in their arrangement as they reach towards the serrated end of the scale. I conceive that the dark longitudinal striæ are not formed by a close combination of interlocked teeth, because I have observed many lacerated scales, which invariably split and tear up the middle of the dark line, and in every such case exhibit a smooth edge without any appearance of teeth. The scales tear down these dark ribs in the same way as some leaves tear easily down the nerves. Moreover it is easy to arrange the lens so as to leave the other parts of the film dark, and the light passing through these longitudinal ribs or striæ in the same way as through the nerves of a leaf. That the cross striæ are thinner than the longitudinal is evident, because when the instrument has been arranged for the most distinct vision of the longitudinal lines, a slight and delicate adjustment of the object *nearer* to the lens throws the longitudinal lines out of the focus and brings out the cross striæ distinctly. Now it is between these two adjustments that the range exists for accurate investigation of the whole phenomena. The cross ribs or striæ may thus be traced running up into the longitudinal, and rising with a curve out of the interstitial furrow.

I would observe also that in consequence of this cross-ribbing of the scale, the longitudinal lines are not the same height all along the scale, but each is liable to irregularities of height at different points, and that this is the cause of the occasionally dotted appearance of the lines for which Dr. Goring blames some microscopes. If the instrument is set so as most distinctly to observe the longitudinal lines, then a slight removal of the object to a *greater* distance will bring the irregular eminences of each line or rib into view.

We are now prepared to observe upon the "mysterious" subject of the diagonal lines. They appear to me to be, as Sir David Brewster states, an optical illusion produced by the arrangement of the cross fibres; a similar effect, on a larger scale, is often observable in printed fabrics for gowns or waistcoats, in which two sets of diagonal lines are seen at a certain distance, but when the pattern is examined closely they are not there. When the scale is removed to a sufficient distance only for showing the cross fibres and not the longitudinal fibres, and the light in the position of the scale is a little oblique, then this delusive appearance takes place. Dr. Goring observes that it was best seen by a lens of moderate power; and certainly, when the magnifying power is only such as not to magnify too much the divisions between the lines, then the delusion of a continued diagonal line is more complete; and it will always appear most complete towards the serrated end

of the scale, because there the cross striæ lie much closer to each other. But if they are examined with more powerful instruments, and the forms adjusted so as to see the rising and sloping portion of the cross striæ, then instead of the diagonal line appearing, the ordinary longitudinal lines will appear "like short hairs or spines in a diagonal direction." In this way they appeared to Mr. Pritchard "through his best instruments." The varieties of appearance seem to me to arise from the instrument commanding at different times the different heights of an uneven surface, and the difference depends upon the distinct vision of the hill, the valley, or the intermediate slope, in a distance which between each longitudinal rib is only the 20,000th of an inch. The cross striæ are about the 60,000th of an inch apart, and near the end of the scale still less.

I remain, Gentlemen, yours, &c.

Burton Latimer, Aug. 31, 1839.

EDWARD CRAIG.

*Description of the Figures. (Plate I.)*

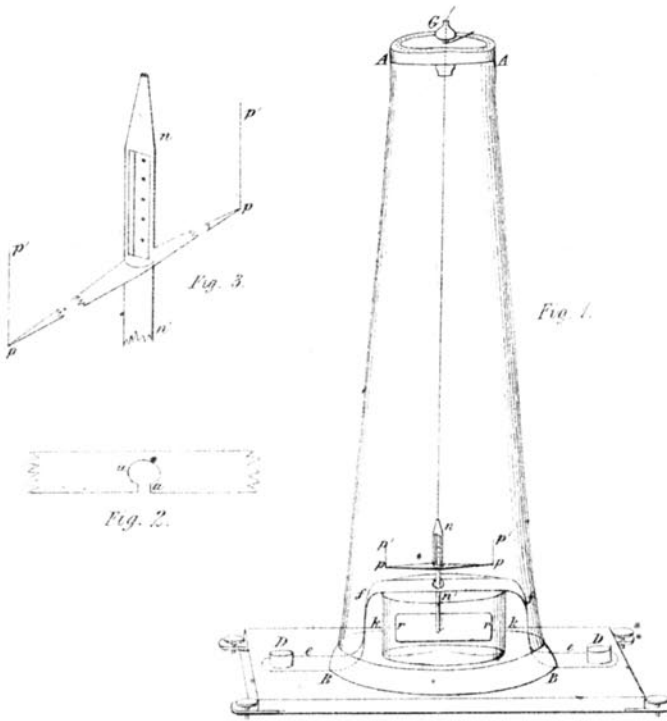
1. A section of the scales, showing the wavy nature of the ribbed surface.
2. A portion of the scale, showing only the longitudinal lines, and torn along one of the fibres.
3. A portion exhibiting the structure of the film, with the longitudinal and cross striæ.
4. A portion in which the dark longitudinal striæ are thrown out of the focus, and only the cross striæ shown.
5. A portion in which the delusive appearance of the diagonal lines is attempted to be imitated.
6. A portion in which the focus of the lens is so adjusted as to show only a portion of the cross striæ on the rising slope of the furrow.

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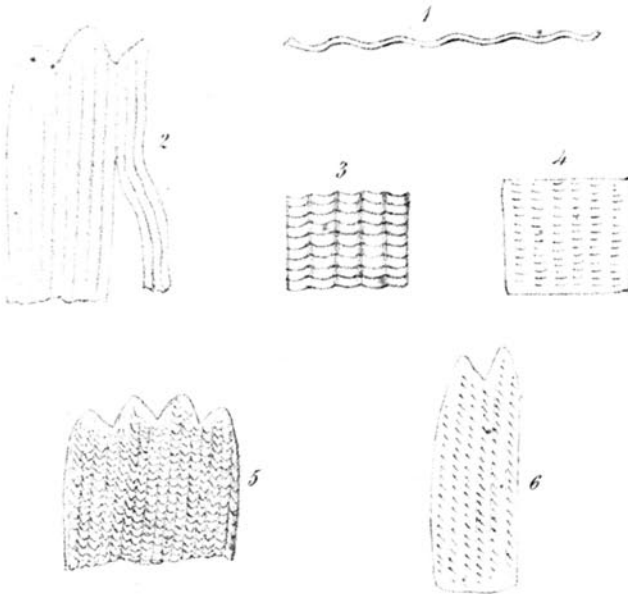
XXXVIII. *On a new Method of distinguishing Arsenic from Antimony, in cases of suspected poisoning by the former substance. By Mr. J. MARSH.\**

I N testing for arsenic in cases of poisoning by that substance, it has always been desirable to render the process as simple as possible, and thereby divest the mind of any ambiguity on the subject. It was with this view that I submitted to the Society of Arts, &c. in the year 1836, my process by hydrogen, a process that I then fondly hoped would have removed all difficulties; but a communication from my friend Mr. Lewis

\* Communicated by the Author.



*Prof. Draper's Improved Torsion Balance.*



*J. Baer, Lith.*

*Scales of Butterfly's Wings, observed by the Rev E. Craig.*