The equations of this paper, however, show that transverse disturbances, and transverse disturbances only, will be propagated through the field, and that the number which expresses the velocity of propagation must be the same as that which expresses the number of electrostatic units of electricity in one electromagnetic unit, the standards of space and time being the same.

The first of these results agrees, as is well known, with the undulatory theory of light as deduced from optical experiments. The second may be judged of by a comparison of the electromagnetical experiments of Weber and Kohlrausch with the velocity of light as determined by astronomers in the heavenly spaces, and by M. Foucault in the air of his laboratory.

Electrostatic units in an electromagnetic unit . .	310,740,000 metres per second.
Velocity of light as found by M. Fizeau	314,858,000.
Velocity of light by M. Foucault	298,000,000.
Velocity of light deduced from aberration . . .	308,000,000.

At the outset of the paper, the dynamical theory of the electromagnetic field borrowed from the undulatory theory of light the use of its luminiferous medium. It now restores the medium, after having tested its powers of transmitting undulations, and the character of those undulations, and certifies that the vibrations are transverse, and that the velocity is that of light. With regard to normal vibrations, the electromagnetic theory does not allow of their transmission.

What, then, is light according to the electromagnetic theory? It consists of alternate and opposite rapidly recurring transverse magnetic disturbances, accompanied with electric displacements, the direction of the electric displacement being at right angles to the magnetic disturbance, and both at right angles to the direction of the ray.

The theory does not attempt to give a mechanical explanation of the nature of magnetic disturbance or of electric displacement, it only asserts the identity of these phenomena, as observed at our leisure in magnetic and electric experiments, with what occurs in the rapid vibrations of light, in a portion of time inconceivably minute.

This paper is already too long to follow out the application of the electromagnetic theory to the different phenomena already explained by the undulatory theory. It discloses a relation between the inductive capacity of a dielectric and its index of refraction. The theory of double refraction in crystals is expressed very simply in terms of the electromagnetic theory. The non-existence of normal vibrations and the ordinary refraction of rays polarized in a principal plane are shown to be capable of explanation; but the verification of the theory is difficult at present, for want of accurate data concerning the dielectric capacity of crystals in different directions.

The propagation of vibrations in a conducting medium is then considered, and it is shown that the light is absorbed at a rate depending on the conducting-power of the medium. This result is so far confirmed by the opacity of all good conductors, but the transparency of electrolytes shows that in certain cases vibrations of short period and amplitude are not absorbed as those of long period would be.

The transparency of thin leaves of gold, silver, and platinum cannot be explained without some such hypothesis.

The actual value of the maximum electromotive force which is called into play during the vibrations of strong sunlight is calculated from Pouillet's data, and found to be about 60,000,000, or about 600 Daniell's cells per metre.

The maximum magnetic force during such vibrations is ·193, or about $\frac{1}{10}$ of the horizontal magnetic force at London.

Methods are then given for applying the general equations to the calculation of the coefficient of mutual induction of two circuits, and in particular of two circles the distance of whose circumferences is small compared with the radius of either.

The coefficient of self-reduction of a coil of rectangular section is found and applied to the case of the coil used by the Committee of the British Association on Electrical Standards. The results of calculation are compared with the value deduced from a comparison of experiments in which this coefficient enters as a correction, and also with the results of direct experiments with the electric balance.

The Induction of Melanism in the Lepidoptera, and its Evolutionary Significance.

By Dr. J. W. HESLOP HARRISON.

IN recent years no more remarkable evolutionary phenomenon has been observed than the development and progress of melanism amongst British native Lepidoptera. Species after species of moth with pale ground colour has given rise to forms so heavily pigmented that they appear in some cases to be dark grey and in others perfectly black. Further, the course of events has not ended with the mere appearance of these melanic forms; in affected species a state of equilibrium has only been attained in the areas concerned when the whole of their representatives has assumed the melanic guise. On Tyneside, for example, twenty-five years ago the species *Boarmia repandata* (the Mottled Beauty) was quite typical; now every specimen captured is black. Moreover, the advance of this progressive melanism is not stayed locally, for new species fall under its influence every year, the latest to yield being *Phigalia pedaria* (the Pale Brindled Beauty) and *Tephrosia bistortata* (the Engrailed).

Clearly, in the development of these melanic insects we are concerned with a very noteworthy phase of evolutionary activity—noteworthy because it is taking place before our eyes. But the importance of the phenomenon does not rest here ; no matter what attempts are made to minimise the connexion, it cannot be denied that upon the industrialisation of the affected area depends the incidence of melanism, or, in other words, the two are related in the way of cause and effect. Thus we are dealing with a case of evolution directed by the environment, and presumably, therefore, of the Lamarckian order.

Naturally, this view has been strongly contested by the opponents of the Lamarckian position, but, let it be emphasised, not one of those so opposed has studied the subject in the field. On the other hand, field workers are unanimous in giving it vigorous support.

At first it was the practice amongst the anti-Lamarckians, in their endeavours to explain it away, to point triumphantly to the absence of melanism in continental industrial areas, and then, when in the end such localities did provide melanic species, to account for them on the basis of chance importations from England. However, the advent of melanic varieties of species like *Cymatophora or* (the Poplar Lutestring) and *Boarmia roboraria* (the Great Oak Beauty) on the Continent, prior to their appearance in Britain (an occurrence depending simply on the fact that the species in question do not approach the smoke zones in Britain as they do in Germany), rendered this position untenable, and a new line of defence was forthwith constructed. Appeal was now made to the failure of melanic forms in the manufacturing districts of the United States. Again the irresistible weight of facts broke down the defence, for the very first species to ‘ go black ’ in England, the Peppered Moth (*Amphidasys betularia*—known in America as *Lycia cognataria*), did the same at Pittsburg. Nor is this an isolated case, for in America Holarctic species like *Tephrosia crepuscularia* (the Small Engrailed), already melanic in Europe, with typically Nearctic forms like *Phigalia titea*, have succumbed to the same influence, to be followed assuredly by many others.

Hence, whether we like it or not, the dependence of melanism on industrialisation must be granted.

With the recognition of this fact, field workers and others very early indeed began to construct theories to explain it, cold, humidity, smoke, soil, and light deficiency all being invoked as inciting agents, either in the crude form of a prime cause or as cogs in a more complex mechanism. The inadequacy of such theories, even when supplemented by natural selection, has already been demonstrated by me in an early[1] paper. In their stead, in the same publication, an alternative suggestion was put forward that metallic salts ingested with the larval food of affected species might so act directly on their germplasm as to alter its potentialities. If such a belief was correct it seemed an easy matter to devise conclusive tests of its validity.

By direct analysis of the deposits on the foliage of trees in Middlesbrough Park, it was discovered that they contained relatively large quantities of salts of manganese, iron, sodium, potassium, and other metals. Furthermore, investigations as to the manganese content of hawthorn leaves near Newcastle-upon-Tyne revealed the presence of unusual percentages of that metal, with a progressive diminution as we passed westward into rural areas.

From these, and other considerations arising out of the peculiar properties of the oxides of manganese, it was determined to supply the larvæ of carefully selected species from nonmelanic regions with food (1) artificially charged with small percentages of manganese compounds, or (2) so contaminated by having been grown within the limits of a smoky manufacturing town. In addition, it was decided to supplement the manganese cultures with parallel ones in which lead salts were employed, the exact salts utilised in the two cases being manganese sulphate and lead nitrate.

Suitable species for the investigations were found in *Tephrosia bistortata*, *T. crepuscularia*, *Selenia bilunaria* (the Early Thorn), and *S. tetralunaria* (the Purple Thorn), all of which under experimental conditions gave rise to melanic individuals. Nevertheless, by far the most important and exhaustive work[2] was carried out with southern strains of *S. bilunaria* and *T. bistortata*.

In the case of *S. bilunaria*, melanics appeared both in the lead and the manganese cultures, the critical lead broods yielding three melanics and fifty-three types and the manganese brood eight melanics and twelve types ; the controls from the same source provided nothing but types.

This induction of melanism had, of course, but little significance unless the melanism was inherited, and in each of these cases, to test this, since melanics of the opposite sexes failed to synchronise in emergence, melanics were paired with types.

The F_1 batches so reared in the lead series, supplied, of course, with untreated food, contained 26 insects, all quite typical ; obviously, if inherited at all, the melanism was acting as a Mendelian recessive. Inbreeding the F_1 insects provided three F_2 batches containing a total of 70 types and 23 melanics—a ratio of 3·04 : 1, which approximates exceedingly closely to the expected ratio of 3 :1.

Similarly, the F_1 manganese family contained only typical insects which, inbred to secure the critical F_2 lots, gave two broods composed of 90 types and 27 melanics—a ratio of 3·3 : 1, again suggesting that melanism was inherited as a Mendelian recessive.

Various matings designed to confirm this were made, with the outcome that, totalling all the figures pertinent to the inquiry, it was found that four families bred from the pairing of homozygous type and homozygous melanic yielded 230 types and 0 melanics, three from heterozygous type × homozygous melanic giving 93 types and 77 melanics, seven from heterozygous type × heterozygous type 363 types and 105 blacks, seven from homozygous

[1] Harrison, " Genetical Studies in the Moths of the Geometrid Genus Oporabia, with a Special Consideration of Melanism in the Lepidoptera," *Jour. Genet.*, vol. 9, 1920.

[2] Harrison and Garrett, " The Induction of Melanism in the Lepidoptera and its Subsequent Inheritance." *Proc. Roy. Soc.* B, vol. 99, 1926.

blacks mated *inter se* 316 blacks and 2 types, and finally, two families of the origin homozygous type × heterozygous type included 132 types, all of which results lead to the same conclusion.

With the results, those secured in the *T. bistortata* work were in perfect agreement—a rather unexpected fact, for, in the Boarmiinae, including the allied *T. crepuscularia*, the melanism, whether induced or natural, is always a Mendelian dominant.

As stated in the concluding remarks of the Royal Society paper (Harrison and Garrett), this work left undecided the question whether it was the metal or the acid radical which played the active part. To determine this, additional work was undertaken with a Saxon strain of *Selenia bilunaria.* This strain, after five inbred generations reared on food charged with manganese chloride, has just (Dec. 19, 1926) supplied three female insects, two types and one melanic, a further induction of melanism rendering it probable that it is to the metal that we have to look for the inciting agent.

No matter what the exact meaning of these experiments, they demonstrate, without any possibility of contradiction, that the germplasm can be influenced by external agencies; therefore, if not of direct Lamarckian import, they lend weighty support to Lamarckian views, for what is in more intimate contact, chemically or otherwise, with the germplasm than the soma?

Irrespective of this, they supply, what evolutionary theories all lack, an experimental demonstration of at least one cause of variation; in fact, they go beyond this, for they actually provide the principle, new in evolution, that food not normal to any given organism may so affect its germplasm as to give rise to heritable variations. This being granted, we see at once how a change in habitat can originate new forms and finally new species.

In no group of organisms would this be more potent than in plants, and thus, instead of an appeal to the sorting out of various genotypes as urged by Turesson [3] to account for the existence of localised genotypes in various plant species, we can conceive of their origin in the stations in which they now exist. So, too, in the variation of cultivated plants influences of the same order are at work.

Nor are animals in Nature exempt from its operations; local races of animals, under the workings of this principle, find a ready explanation, and so do the various forms into which wild animals break when domesticated. In no group of animals are its workings so beautifully illustrated than in the Insecta, particularly in the phytophagous groups.

Often enough, owing to the preference of plants to grow in definite associations, different species of plants grow intermingled. What then is more likely than the accidental transference of eggs or larvæ to the wrong foodplant? Is not the difference between species chemical? If larvæ so transferred react as in the experimental work, new [4] phytophagous races or species must arise, isolated by their attachment to a special foodplant, and induced to vary from the type from which they were derived by the influence, exerted chemically, of that foodplant. Of insects so related to one another, even in our own restricted fauna, we have many; for example, the moth *Cerura biscuspis* is purely an alder feeder, whilst its congener *C. furcula* takes sallow, the Aleurodid *Tetralicia vaccinii* feeds on bilberry, and *T. ericae* on *Erica tetralix*, the gall-gnat *Loewiola centaureae* parasitises *Centaurea nigra* and its relative *L. serratulae, Serratula tinctoria*, and so the list could be extended to all insect groups.

[3] Turesson, "The Plant Species in Relation to Habitat and Climate," *Hereditas*, vol. 6, 1925.

[4] As demonstrated by me in the case of the Gallmaking sawflies of the genus Pontania in a paper now in the press.

Electro-deposition of Rubber.

FROM recent announcements in the press it would appear that some considerable changes are likely to take place in the technology of rubber as the outcome of patented developments in the process of rubber electro-deposition. So promising have been the results obtained that the American rights in the various patents concerned have been transferred from their original owners, the Anode Rubber Co. of Great Britain, the B. F. Goodrich Rubber Co., and the Eastman Kodak Co., to a new company called the American Anode, Inc., for independent exploitation. The British rights, it is understood, have just been acquired by the Dunlop Rubber Co. and its associated concerns. It is perhaps too soon yet to estimate the commercial value of the whole process, for it can only be regarded as emerging from the experimental stage; but the fact that strong financial support is already forthcoming furnishes presumptive evidence of its value.

The possibility of rubber electro-deposition dates back to 1906, when Henri observed that in rubber latex, which is a colloidal suspension of rubber particles in a serum, the particles are negatively charged and migrate to the anode under the influence of a direct electric current. The observation found early practical application in Cockerill's process, patented in 1908, for removing rubber from latex by depositing it electrically upon a moving anode; but as this process led only to the production of crude rubber—in fact it was only intended for the coagulation of rubber from latex prior to shipment—its commercial scope was limited. The importance of the recent developments in this field arises from the discovery, made independently in 1922–23 by Klein in Hungary and by Sheppard and Eberlin in the United States, that all the ingredients essential to the production of finished rubber articles, namely, the sulphur required for vulcanisation purposes, many fillers and other compounding ingredients, as well as organic dyes and vulcanisation accelerators, can be admixed in a finely divided state with rubber latex or even with an artificial dispersion of rubber, and that the whole adsorption compound produced can be electrically precipitated as a homogeneous