starlings. I have also found two young birds of the Molothrus nearly fully feathered in the nest of a starling; but in this instance the young starlings had been ejected from the nest." He then states that he had long kept in confinement a male and female of this species of Molothrus, which are now six years old. The hen began to lay at the age of two years, and has laid each time six eggs, which is the number laid by Icterus, a near ally of Molothrus. The dates on which the eggs were laid this year are as follows:—February 1, 6, 11, 16, 21, and 26; so that there was an interval of exactly four clear days between the laying of each egg. Later in the season she laid six additional eggs, but at much longer intervals and irregularly, viz. on March 8, April 6 and 13, May 1, 16, and 21. These interesting facts, observed by Mr. Nation in relation to a bird so widely distinct from the cuckoo as is the Molothrus, strongly support the conclusion that there is some close connection between parasitism and the laying of eggs at considerable intervals of time. Mr. Nation adds that in the genus Molothrus, out of every three young birds he has invariably found two to be males; whereas with Sturnella, which lays only three eggs, two of the young birds are, without any exception, females.

CHARLES DARWIN

Down, Beckenham, Kent, November 7

The Velocity of Light

IN reply to Mr. Macaulay (NATURE, vol. xxiv. p. 556) I will endeavour to explain more clearly the statements, made in my former communication on this subject (NATURE, vol. xxiv. p. 382). On one important point the explanation will include a correction.

With reference to the group-velocity U, we know from Fourier's theorem that any disturbance travelling in one dimension, can be regarded as resulting from the superposition of infinite trains of waves of the harmonic type, and of various amplitudes and wave-lengths. And we know that any one of these trains, of wave-length λ, is propagated unchanged with a velocity V, which we regard as a known function of λ, dependent upon the nature of the medium.

Unless we can deal with phases, a simple train of waves presents no mark by which its parts can be identified. The introduction of such a mark necessarily involves a departure from the original simplicity of a single train, and we have to consider how in accordance with Fourier's theorem the new state of things is to be represented. The only case in which we can expect a simple result is when the mark is of such a character that it leaves a considerable number of consecutive waves still sensibly of the given harmonic type, though the wave-length and amplitude may vary within moderate limits at points whose distance amounts to a very large multiple of λ. We will therefore suppose that the complete expression by Fourier's series involves only wave-lengths which differ but little from one another, and accordingly write it—

$$a_1 \cos\{(n+\delta n_1)t-(\kappa+\delta\kappa_1)x+\epsilon_1\} + a_2\cos\{(n+\delta n_2)t-(\kappa+\delta\kappa_2)x+\epsilon_2\}+\ \dots\ ,$$

or in the equivalent form—

$$\cos(nt-\kappa x)\,\Sigma a_1\cos(\delta n_1 t-\delta\kappa_1 x+\epsilon_1) - \sin(nt-\kappa n)\,\Sigma a_1 \sin(\delta n_1 t-\delta\kappa_1 x+\epsilon_1),$$

where $\kappa=2\pi/\lambda$, and $n=\kappa V$. From this we see that, as in accordance with the suppositions already made,

$$\frac{\delta n_1}{\delta\kappa_1}=\frac{\delta n_2}{\delta\kappa_2}=\ \dots\ =\frac{dn}{d\kappa},$$

the deviations from the simple harmonic type travel with velocity $dn/d\kappa$, and not with velocity n/κ, that is with velocity $d(\kappa V)/d\kappa$, and not with velocity V.

I now pass on to the theory of Foucault's experiment. If D be the distance between the fixed and moving mirrors, ω the angular velocity of the latter, then the angle through which the mirror turns in the time occupied by the wave in making the double journey is $2D\omega/V$, and the angular deflection θ, which is the immediate subject of observation, is according to the usual view—

$$\theta=\frac{4D\omega}{V}.$$

Now it is here assumed that the deflection is due merely to the change of position of the mirror between the two reflections, and that the wave returns to the mirror with its front parallel to the position occupied immediately after the first reflection, as would be the case if the mirror were at rest. But if V be a function of λ, this assumption is not true. Besides the deflection above considered, there is another depending upon the fact that the wave front rotates in the air between the two reflections. The rotation is a consequence of the inclination to one another of successive wave fronts, which involves a variation of wave-length and therefore of velocity at points situated on the same wave-front in a line perpendicular to the axis of rotation. Denoting distances measured along this line by x, we have for the angular velocity of the wave's rotation—

$$\omega'=\frac{dV}{dx}=\frac{dV}{d\lambda}\frac{d\lambda}{dx},$$

in which $d\lambda/dx$, representing the angle between successive wave-fronts of similar phase, is equal to $2\omega\lambda/V$. Accordingly—

$$\omega'=2\omega\frac{d\log V}{d\log\lambda},$$

and the actually observed rotation is—

$$\theta=\frac{4D\omega}{V}\left(1-\frac{d\log V}{d\log\lambda}\right).$$

The result of a calculation which leaves the aërial rotation out of account is therefore not V, but—

$$\frac{V}{1-\frac{d\log V}{d\log\lambda}}$$

Now

$$U=\frac{d(\kappa V)}{d\kappa}=V\left(1+\frac{d\log V}{d\log\kappa}\right)=V\left(1-\frac{d\log V}{d\log\lambda}\right);$$

so that the result of the experiment is V^2/U, and not as previously stated the group velocity U itself. The error arose from a mistake as to the direction of the effect of ω'.

The force of the arguments which I founded upon these considerations is increased rather than diminished by the correction, and with Mr. Michelson's evidence on the same side of the question almost excludes any appreciable variation of V. It should be noticed that by the combination of the two methods of the toothed wheel and of the revolving mirror we have the means of determining both V and U, and the results of Cornu and Michelson appear to prove, independently of astronomical observation, that there is no sensible difference between them.

Indeed by a slightly varied arrangement it would seem possible to determine V directly from Foucault's experiment. If a convex lens were so interposed at the distant station that the fixed mirror occupied its focus, the sides of short and long wave-length would be interchanged, and thus the rotation acquired during the outward journey would be neutralised during the return.

RAYLEIGH

The Struggle of Parts in the Organism

I AM very glad to learn that Mr. Romanes fully accepts as "well-known and unquestionable" the definition of the term *law of nature* which I propounded as expressing its true scientific sense; but I would suggest to him, as to other writers who are accustomed to speak of such laws as "governing" phenomena,[1] whether the use of such "metaphorical" language is not objectionable, as tending to keep up in the *un*scientific mind the notion of the "coercive" and "self-sufficient" agency of natural laws. I am glad also to be able to express my entire accordance with Mr. Romanes in regard to the inferiority of the teleological argument based on *special instances* of adaptation of means to ends, to that which is based on the *general order* which we designate by the term law. For I maintained this view even in that remote pre Darwinian age in which my scientific life commenced, urging to the best of my young ability, forty-three years ago,[2] that the principles admirably laid down by Whewell in regard to physical inquiry, viz. that final causes should be excluded, because "we are not to assume that we know the objects of the Creator's design, and put the assumed purpose in the place of a physical cause," and that "the notion of design and end is transferred by the researches of science from the

[1] I continually meet with this phrase in the pages of NATURE.

[2] See *British and Foreign Medical Review* for April, 1838: "Physiology an Inductive Science."