twenty times the original standard deviation. "Student" uses these data, together with reasonable estimates of the intensity of selection, to obtain an estimate of the least possible number of factors which must be postulated to obtain the results up to the date of the report; he concludes that at least 100–300 factors would be needed; and, taking into account the complete lack of evidence that selection is nearing its limit, considers that it is more probable that the actual number of factors is measured in thousands.

Estimates of the number of factors needed to explain quantitative inheritance are beset with considerable difficulty, and "Student" has admitted to me in correspondence that his calculation fails from over-simplification. Other well-established phenomena in maize, however, such as the flood of recessive defects revealed by every plant which has been used to found a selfed line, combined with the inevitable rarity of each of these defects, taken individually, in the population from which the foundation plant was selected, force one to the conclusion that all commercial varieties must be segregating in hundreds, and quite possibly in thousands of factors influencing the normal development of the plant. This emphatic experience, has, I believe, killed among maize breeders all those doctrines concerning the supposed inefficacy of the selection of minute differences, with which the teaching of modern genetics was at first encumbered.

It should be emphasised that the result of importance for evolutionary theory is not that the number of factors must be very large, thousands for example, rather than hundreds, but the direct demonstration that selection has the exact effects that selectionists have ascribed to it, without the limitations by which its action has been supposed to be restricted, on the strength of an early misapprehension as to the number and variety of the Mendelian factors exposed to its cumulative action.

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[1] *J. Agric. Res.*, **39**, 451–476; 1929.

Fourier Analysis and Vowel Curves

IN NATURE of December 24, p. 965, Prof. E. W. Scripture discussed difficulties in applying Fourier analysis to recorded vowel curves, and he published two illustrations of the latter. The second of these, or at least what the corresponding curve would have been if the process of ground noise suppression had not been used in the recording, is strikingly similar to a curve I once drew up to illustrate complex modulation of a carrier wave in radio. The 'interior waves' correspond to the carrier wave, and the regular repetition or pattern corresponds to the so-called 'modulation envelope'.

This suggests that an alternative method of analysis, the applicability of which to a vowel curve similar to that published might repay investigation, would be to consider the vowel curve as that of a 'carrier note' undergoing modulation, the modulation being not necessarily sinusoidal but perhaps more complex. For example, the 'modulation envelope' of the published curve approximates to a saw-tooth form.

This method of analysis might not really be an alternative to Prof. Scripture's method, and might only be an alternative method of stating the latter. An artificial 'vowel curve' corresponding to saw-tooth modulation or other arbitrary modulation would make an interesting test of Prof. Scripture's and of other methods of analysis. Incidentally, such an artificial vowel curve could fairly easily be recorded and reproduced, and the electrical equivalent of it could be generated and reproduced directly without recording.

It may be worth while considering the bearing on these considerations of the fact that a modulated wave may be analysed into a carrier *plus* side-bands. A wave form approximating to a 'saw-tooth' modulated carrier can be constructed out of the carrier and a small number of side bands, all undamped waves. The general appearance of such a wave form would be similar to that of the vowel curve published, and therefore would afford (though in this case erroneously) just as strong grounds for holding that the wave form was inconsistent with analysis into undamped waves and that it required an analysis into damped waves.

The point which emerges from this is that Fourier analysis is not the only analysis into sinusoidal components. Consider a sinusoidally modulated carrier represented by $A(1+k\sin pt+\alpha)\sin\omega t$. If the carrier frequency, $\omega/2\pi$, is much greater than the modulation frequency, $p/2\pi$, the resulting wave form *seems* to be periodic at frequency $p/2\pi$, because the modulation envelope is periodic at this frequency. Close examination of the curve, or mathematical examination of the formula, shows, however, that the carrier waves in one cycle of the modulation frequency are situated differently with respect to the modulation envelope from those in another cycle, there being a phase difference. Unless ω is a multiple of p, the wave is not periodic at frequency p, and unless ω and p are commensurate there is no true period at all. Fourier's analysis is therefore not applicable, but this does not prove definitely that analysis into sinusoidal components is not possible.

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Photography of Faint Transient Light-Spots

PROF. H. HARTRIDGE in his letter in NATURE of January 21, expresses the need for "A lens having a numerical aperture of 0·8 or 0·7, a focal length of 25–50 mm. and adequate definition on the film over an area of 3–5 mm." It is perhaps not commonly noticed that a Mangin lens-mirror out of a motor-car headlight has just about this specification. I have used such a mirror to photograph a cathode ray oscillogram. The definition, though not what one would desire, was yet good enough to be useful.

Apparently there is no other commercial type of optical system that has both the large numerical aperture and the long focal length required, together with passable definition; but I should be glad to be corrected. The tiny image of an achromatic substage condenser was spoilt by scattering in the emulsion.

Some Mangin mirrors are purposely made with considerable spherical aberration on the axis, of a type thoroughly described by A. C. W. Aldis[1]. This aberration can, I find, be very simply corrected by placing a block of glass, having plane parallel faces,