Letters to the Editor.

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The Quantum Theory and Homogeneous Vibrations.

IN the quantum theory as usually presented a finite amount of energy is associated with a periodic disturbance which is called "homogeneous." I desire to raise the question whether the use of that term is defensible. Both in optics and in acoustics the word "homogeneity" has acquired a definite meaning which is inconsistent with its application to quanta. In fact, the affirmation of quanta involves a denial of homogeneity. To avoid misunderstandings and obscurities we must either abandon the hitherto recognised definition of that word as applied to oscillations, or avoid its use in the formulation of the quantum theory. I submit that the second alternative is preferable.

A homogeneous vibration as hitherto understood is unlimited in time, just as a homogeneous wave is unlimited in space; a disturbance having velocities proportional to $\cos nt$ is homogeneous only if it applies to all values of t, however great, on the positive and negative sides. As soon as limits are imposed the oscillation ceases to be homogeneous. The radiation of a quantum, if expressed by a circular function, being necessarily limited in time, it follows that homogeneity is impossible. If the velocity of the oscillator be represented by $e^{-kt}\cos nt$, the exponential factor admits quanta because it allows us to assign a finite value to the total energy, but it destroys at the same time the homogeneity. When analysed practically by the spectroscope or theoretically by Fourier's theorem, *all* frequencies are represented, though when k is small nearly the entire energy is concentrated in a narrow region closely adjoining that of the maximum intensity which takes place at frequency $\sqrt{n^2-k^2}$. We must conclude that the radiation associated with a quantum is not homogeneous, though its effective energy is confined to a narrow region of frequencies. If an expression be required to represent the nearly homogeneous radiation of a quantum, we shall perhaps commit ourselves least to any definite views by calling it simply a "quantum radiation."

ARTHUR SCHUSTER.

Yeldall, Twyford, Berks, April 10.

Variegation in a Fern.

IN the Croonian lecture (Proc. Roy. Soc., B, vol. xci., p. 368) I said that the prothallia of a variegated Adiantum were entirely green, though the ferns which arise from them may be green, or variegated, or white. This statement should be corrected, for I find that though the prothallia look all green when growing on the soil, some of them have lighter, occasionally almost white, patches, which are seen as soon as the prothallia are examined by transmitted light. These patches of cells are sharply defined, usually forming radiating bands widening peripherally. In some cases the light tissue is an island of cells entirely surrounded by the green cells. The plastids in the light cells are at least as numerous as those of the green cells, but they are smaller and pale in colour, being mostly a faint green, though sometimes almost colourless. The development of this kind of variegation will need careful study. It is difficult to avoid the inference that genetic segregation does here occur in haploid tissue, but the process is not necessarily postponed, as I suggested, to the formation of the germ-cells.

W. BATESON.

The John Innes Horticultural Institution,
April 14.

The "Flight" of Flying-fish.

I HAVE recently received the following information on the "flight" of flying-fish from Prof. Wood-Jones, the well-known anatomist and naturalist. His conclusions based on his own observations must carry weight, and, in my opinion, should finally settle the points in dispute.

DAVID WILSON-BARKER.

Many years ago I watched flying-fish daily for hours on end, and I think that observations made, as were mine at that time, from the long overhang of the bow-sheaves of a cable ship are far better than those made by casual observers from the decks of a passenger vessel; for, in the first place, the observation is made many yards ahead of the cut water, and the fish can be observed swimming just below the water and then breaking its surface and taking "flight"; and, in the second, observations can be taken when the ship is steaming no more than 1½ knots. As a result of my spell in cable ships in the Indian Ocean I had no doubt as to the manner of "flight" of flying-fish, and, though directly antagonistic ideas seem prevalent to-day, I still, after a further series of observations, have no doubt that flying-fish gather all their impulse by the lateral movements of their tail as they leave the water and then sustain themselves in the air by what would now be termed "planing."

In order to check my previous conclusions, I made observations and notes on this matter during a journey to Australia last year, and also during a trip to Honolulu and back. On both these occasions I took care to interest any children in the question, for children are commonly good judges in such things. On both occasions I secured a specimen which came aboard, and the accompanying rough figures are made from the dissection of one of these.

These observations may be summarised as follows:

(1) Flying-fish when disturbed by an oncoming vessel dart about beneath the surface with the greatest rapidity. Some members of a shoal seek safety by their speed below water with their *pectoral fins tight adpressed to their sides*; some with a rush break the surface of the water, *spread their pectoral fins, and plane away.*

(2) The impulse is gathered by the final very rapid lateral movements of the tail as the fish leaves the water.

(3) When the fish springs into the air it quivers all over. This quivering is seen in the spread pectoral fins, but this is not a very rapid wing-stroke—as seen, say, in a drone-fly; it is merely the vibration due to the great rush with which the creature cleaves the water.

(4) Once launched in the air the pectoral fins are spread out as planes and remain motionless.

(5) Fresh impetus can be gained from time to time by the tail dropping to the water and powerful lateral movements being produced with the enlarged lower fluke of the caudal fin.