Letters to the Editor.

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The "Flight" of Flying-fish.

HAVING read with interest the letters by Prof. Wood-Jones and Mr. Julian S. Huxley in NATURE for April 21 and 28 respectively, I send some observations of my own which seem to have a bearing on this subject. In the early 'nineties I was engaged in the development of the meteorological kite of the Hargrave pattern, which was adopted at the Blue Hill Observatory for lifting self-recording apparatus in the air, and later adopted by the various bureaux of the world for aerological research. This work brought me in contact with the early pioneer workers on the problem of flight in the United States—Langley, Chanute, the Wrights, Cabbot, Means, Millet, and others—and I occasionally co-operated in experiments on the lifting and driving powers of various devices. One of these was a device in which a stiff rod had attached to one end a flexible rod of bamboo, one end of the bamboo strip being tied near the end of the rigid rod and the other about one-fourth of the way down, so that the bamboo rod formed a loop, over which was drawn a covering of cloth. Now, if one took the free end of the rigid rod and waved the end containing the bamboo loop up and down, he was immediately turned round by a forward motion of the outer end of the rigid rod. The reason of this clearly was that when he lifted the rigid rod upward the flexible loop bent downward, and there was a component of air pressure forward, while when he moved the rigid rod downward the flexible loop bent upward, and there was still a component of air pressure forward. When vibrating the rod up and down there was a persistent forward thrust, and this thrust was so great when the vibration was rapid that the operator was turned completely around in his tracks as on a pivot.

In 1905 I was in charge of the Tieserenc de Bort and Rotch Expedition for exploring the atmosphere with balloons and kites over the tropical part of the Atlantic. The *Otaria*, on which we travelled, was a small boat not much more than 100 ft. in length, with the decks near the water, so that I had an excellent opportunity of studying the movements of flying-fish, which we saw in great numbers.

As these fish left the water the powerful lateral strokes of the tail which lifted them into the air could be plainly seen. As they rose into the air the pectoral fins vibrated with great rapidity, and my earlier experiments with the rod and flexible web led me to believe that exactly this same principle was used by the flying-fish to drive itself forward. The forward part of the pectoral fin is rigid and the rear flexible, so that its rapid vibration gives a strong propelling force. When the fish had gained velocity and the rising impulse given by the tail had culminated, the fins ceased to vibrate and were used as aeroplanes, on which it glided forward, slowly sinking until its tail touched the water, when another lateral stroke lifted it into the air and the process was repeated. In this way the fish could remain in the air for long flights when necessary. The only way in which the motion differs from the flight of birds is that the vibration of the fins probably gives no lifting force, but only a forward driving force, and the fish needs to depend on the tail-strokes for the lift. Had the

fish developed a concave under-surface of the fin it could probably have obtained both lifting and propelling force from the fins. H. H. CLAYTON.

Oficina Meteorologica, Buenos Aires,
June 20.

The Colours of Breathed-on Plates.

THE phenomena of breath-figures on glass are of considerable interest, and have been written upon in the columns of NATURE by the late Lord Rayleigh, Dr. John Aitken, and others. One specially interesting aspect of the subject to which I have recently devoted some attention is the explanation of the beautiful optical effects exhibited by breathed-on plates of glass. If a clean, cold plate of glass is lightly breathed on and then held in front of the eye, and if a small distant source of light is viewed through it, coloured haloes will be seen surrounding the source. The characteristic feature of the halo exhibited by a moderately heavy (but not too heavy) deposit is that the outermost ring in it is achromatic, with a reddish or brown inner margin, followed inside by a succession of rings of various colours. As the film of moisture evaporates, the halo contracts and the coloured rings move inwards, ultimately disappearing at the centre of the halo. The entire halo presents a radiating fibrous structure.

The explanation of these phenomena presents some difficulties. One is tempted to suppose (as, indeed, Donlé and Exner have already) either that the minute droplets of water condensed on the plate which diffract the light are of approximately equal size or that they are arranged at more or less constant distances from each other. A microscopic examination of the condensed film shows, however, that neither of these suppositions is anywhere near the truth. The size of the individual droplets shows a variation of several hundred per cent., and their arrangement in the film is entirely irregular, being determined presumably by the presence of invisible condensation nuclei on the surface of the plate—a view that is strongly supported by the fact that successive deposits on the plate are seen under the microscope to preserve the same configuration with a surprising degree of accuracy. Further, if the size of the droplets were the determining factor in the production of the diffraction haloes, it would be difficult to understand why as they evaporate the rings in the halo should contract in size.

These facts necessitate an entirely different supposition regarding the element of regularity in the film which enables it to give rise to a recognisable system of coloured diffraction haloes. Measurements I have made seem to show that the droplets in the film—whether large or small—have practically all the same angle of contact with the surface of the plate, this angle of contact diminishing as the film evaporates. The formation of the coloured haloes is, on this view, due to the passage of the light through the minute lens-shaped droplets; the maximum deviation of the light determined by the common angle of contact fixes the position of the outermost achromatic halo, and the colour-sequence following within it would be practically the same for all the droplets irrespective of their size. This would also furnish a satisfactory explanation of the contraction of the halo as the film evaporates. C. V. RAMAN.

22 Oxford Road, Putney, S.W.15, July 26.

Mutations and Evolution.

THE article on my recent little book on "Mutations and Evolution" in NATURE of July 14, p. 636, shows such insight in the exposition of some of the views